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A NEW ODONTOGRAPH.

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An odontograph can be based on the fact that if the shape of the teeth of a rack consists of two congruent branches, corresponding points of which meet tangentially in the pitch line, any two gear wheels correctly gearing into this rack will also correctly gear with one another.

The construction and mode of application of this odontograph is as follows: To a bar, *A*, Fig. 1, representing a rack, one edge of which (the pitch line) is carefully straightened, is attached a template, *T*, of a tooth carefully filed so that each side consists of two equal curves meeting exactly in the pitch line. The mode of attachment is such that a space, *S*, is left between the bar and that part of the template representing the tooth. To delineate the form of teeth of a required gear wheel, it is only necessary to procure a circular plate, *B*, or a portion of such a plate, of a diameter equal to the pitch diameter of the required gear wheel, and fasten to it a piece of sheet metal, *t*, upon which the tooth can be constructed by what was probably the first method ever employed to design properly shaped gear wheels, namely,

by rolling the disc *B* on the bar *A* (or *vice versa*) and marking with a fine scriber the tooth, *T*, in a number of positions on the template sheet, *t*. (See Fig. 2.) A band of very thin steel, one end fastened to the rack, the other to the wheel-plate, may serve as a means to pre-

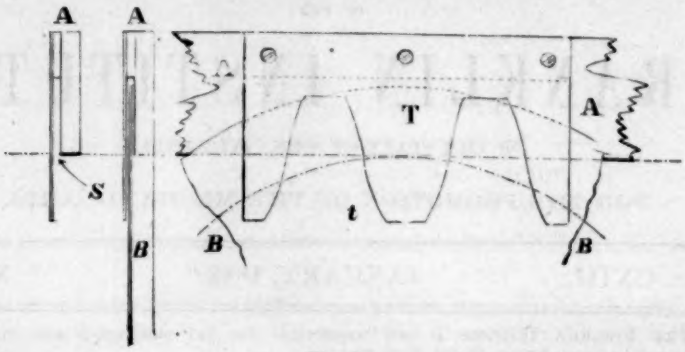

Fig. 1.

vent slipping. The form thus delineated, or enveloped, can then be cut and filed to complete the secondary template, *t*. It is advisable to have this latter template extend to the centre of the plate *B*, for the reception of a concentrical hole, suitable to its future use, to insure radial position and proper distance from the centre of the wheel.

If the gear wheels made in this way are required to have clearance or play, the width of the template tooth, *T*, should be greater than one-half the pitch, its height above the pitch line greater, and its depth below it less than one-half the total height of the tooth.

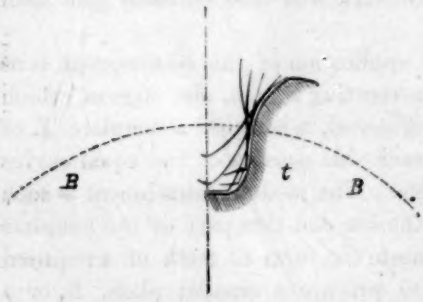

Fig. 2.

The template *T*, as shown in the drawing, contains the sides of the adjacent teeth. By its use, the secondary template will have two teeth, one of which may be employed for marking the tooth to be laid out, the other one will serve as a means of checking the distance of teeth.

This odontograph can be employed for the construction of epicycloidal as well as involute teeth, or for any intermediate form. For epicycloidal teeth, the form of the original template must consist of two cycloids developed by the roll-

ing of a circle on the pitch line of the rack. The diameter of this rolling circle, as is well known, should be equal to the pitch radius of the smallest pinion likely to be required for the set of gears. For involute teeth, the tooth of the rack should be defined by straight lines, of an angle of about 75°. But also any other suitable form may be used, provided it is within certain conditions. In cast bevel wheels, for instance, purely cycloidal gears have the one objection of being without "draft" near the pitch cone, while involute teeth are objectionable owing to their less regular wear compared with cycloidal gears. To meet this case, the original template may be made almost identical with the cycloidal form (see dotted line of Fig. 3) but slightly deviating near the pitch line to produce "draft."

The proper shaping of the teeth of gear wheels of irregular shapes, for instance of elliptical wheels, can likewise be accomplished, for this odontograph makes such teeth theoretically correct. For internal gear wheels, the described method is equally applicable, as it can be shown that for interchangeable gear forms, the inverted gear must be an exact counterpart of an external or spur wheel of the same size, excepting as regards the allowance for clearance. Respecting internal gear, however, another explanation is in order, namely, as regards the fillet described by this odontograph at the base of the teeth. Owing to this fillet, the points of the inverted or annular gear-wheel teeth would become rounded off by the mere inversion of an equal sized spur wheel described by this odontograph, which is equivalent to a shortening of the teeth and a consequent reduction of the number of teeth in gear at the same time. This number is, however, generally abundant with internal gear, and the reduction alluded to unimportant. But if it is considered an objection, the remedy consists in making the template tooth of the describing rack very long for *both* the internal and the inverted gear and, after the construction of the form, reducing the height of the teeth to suit.

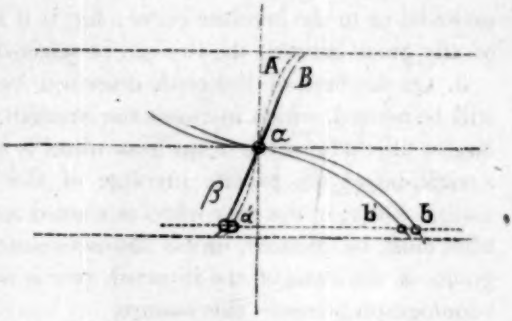

Fig. 3.

The herewith proposed mode of laying out gear wheels thus includes almost every imaginable modification pertaining to the subject.

The advantages in favor of this odontograph, for practical use, may be said to be as follows:

1. The forms obtained by it are not only approximately but theoretically correct, provided the original template is properly made, and by the use of auxiliary templates any desirable degree of accuracy can be obtained in this respect.

2. The degree of inaccuracy in workmanship is materially reduced as compared with teeth laid out by circular arcs or their intersections, by reason of the difficulty attending the placing of the centre point of the compasses in the exact location.

3. The handling and application requires no great intelligence, but simply skill and care.

4. In the original selection of form, one is not confined to the cycloidal or to the involute curve; for, if it is desired, an intermediate of any grade between the two can be selected.

5. On the base of the teeth described by this odontograph a fillet will be noticed, which increases the strength of the teeth. This is the largest fillet admissible if the gear wheel is ever required to gear into a rack, being the prolate involute of the corner-point of the rack tooth. Only, if the gear wheel is wanted for an internal gearing, the fillet must be reduced, unless the above-mentioned rounding of the points of the teeth of the inverted gear is not objected to. No other odontograph possesses this feature.

The principle of this odontograph may even be used in the construction of a gear-cutting machine, to give theoretically correct shapes. Suppose a shaping machine, provided with a tool of the shape of a rack tooth, would, by the cross-feed, produce a simultaneous rotation of the wheel to be cut, or rather corrected, say by means of a thin steel band running over a cylinder of the diameter of the pitch-circle of the wheel. This operation is identical with the above-described application of the odontograph. The same tool will give the proper form to all wheels, large or small, of the same set. This plan would even be applicable to the cutting of theoretically correct bevel wheels, by cutting only one side of a tooth at one time, especially if the involute form of teeth is adopted. For practical reasons, however, it is doubtful whether such machines would be commercially successful.

The Theory.

In order to prove the assertion which forms the base for the foregoing, the conditions should first be well understood which make a set of gear wheels interchangeable, *i. e.*, which make it possible that any two of them will correctly gear into one another. Two wheels gear correctly, if the velocity is transmitted precisely as regular as it would be by simple contact (without slip) of two true cylinders.

It is well known that if only one pair of wheels are to be made, the tooth-form of one of the wheels is, within certain limits, arbitrary, and the corresponding tooth-form of the other wheel may be obtained by a rolling of the pitch-circles and making the tooth of one wheel describe that of the other. If the pair of wheels thus constructed are in operation with their centres in fixed positions, it will be noticed

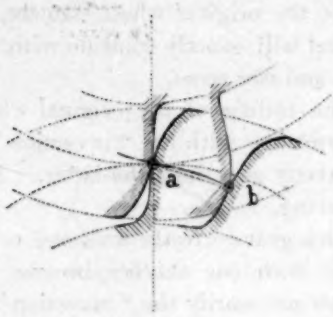

Fig. 4.

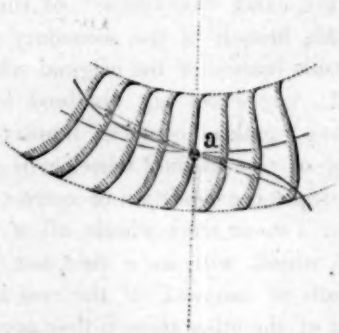

Fig. 5.

that as one tooth pushes the other one forward, the point of contact is continually changing and, if followed, is found to describe a continuous curve, the "path of contact." If the motion is arrested at any point (see Fig. 4) and a line drawn connecting the point of contact of the teeth, *b*, with the point of contact of the pitch lines, *a*, this line will be found to be normal (at right angles) to the curves of *both* teeth in the point *b*. This is the well-known condition of correctly gearing tooth-forms and, in fact, a necessary result of the manner in which the form of one tooth has been developed by the other; for at the moment when the point *b* of the second gear was developed by the rolling, the relative centre of motion was in the point *a*.

The line *a b* being a normal to the curves of both teeth, it is certainly a normal to each of those curves individually, and therefore it

is possible to construct the path of contact solely from the originally adopted tooth-form of the first wheel, before the second wheel has been constructed or even contemplated. The proceeding for accomplishing this purpose is as follows: Draw the original tooth in a number of successive positions, and from the intended point of pitch-contact, *a* (Fig. 5), normal lines to these curves. The line connecting the roots of these normals is the sought curve.

From the preceding, these conclusions can be drawn:

1. The "path of contact" of any gear wheel, when in gear, depends solely on its own tooth-form and is independent of the size of its mate, provided the mate gears correctly. We can, therefore, speak, as it were, of the "path of contact" of a single wheel.

2. Any one of a number of wheels made to gear with an original wheel of arbitrary tooth-form will possess a "path of contact" which is the exact "inversion" of that of the original wheel, namely, the inside branch of the secondary wheel will exactly coincide with the outside branch of the original wheel and *vice versa*.

3. Any wheel not obtained by the rolling of the original wheel, whose "path of contact," however, coincides with the "inversion" of that of the original wheel, will correctly gear into the latter. This expresses the condition of correct gearing.

4. Two or more wheels, all of which gear correctly with one original wheel, will, as a rule, not gear with one another, because the "path of contact" of the one is not necessarily the "inversion" of that of the other though they are congruent. But if this should happen to be the case, namely, if both branches, inside and outside, of the "path of contact" would exactly coincide with each other, all secondary wheels would gear with one another. This constitutes the condition for interchangeable gear wheels, and a few additional words will complete the proof for the correctness of the original assertion upon which the construction of the odontograph is based.

Supposing the original gear wheel would have been one of an infinite radius, a rack, the preceding contemplations and deductions would be equally applicable. Considering the mode of constructing the "path of contact," it is plain that if one rack is the "inversion" of another (*i. e.*, if the teeth of one rack exactly fit the spaces of the other), its "path of contact" is likewise the "inversion" of that of the other; and if any two gear wheels are made, one of which to gear with the one rack and the other to gear with the other rack, both

these gear wheels will correctly gear with one another; and if, further, one rack is made to coincide with its own inversion, *i. e.*, if it answers the condition expressed at the beginning, all wheels gearing into it possess equal and inversible "paths of contact" and will, therefore, gear with one another.

The introduction of the "path of contact" (instead of the rolling curves) as a base for the theory of gear wheels materially facilitates the study of their action. A few instances in this respect are herewith presented.

General Remarks.

The two principal systems of interchangeable gear wheels now in use are the cycloidal and involute forms. The "path of contact" of

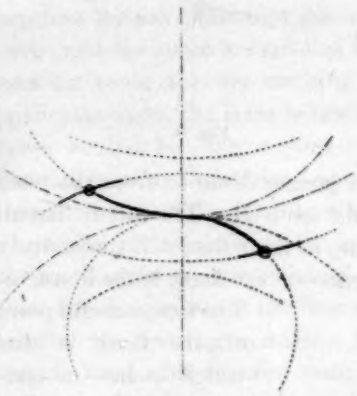

Fig. 6.

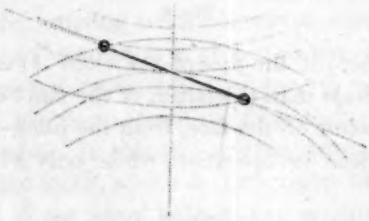

Fig. 7.

the former is identical with the rolling circles by which the cycloids are evolved (see Fig. 6), while that of the latter is contained in the right line passing between and touching both evolute circles (Fig. 7).

The well-known fact that involute wheels will gear correctly, even if the distance of centres is slightly changed, can thus readily be accounted for. The "paths of contact" being straight lines, it is not necessary to locate the centres of the wheels at a precise distance to make the paths of both wheels coincide.

By means of the "path of contact" (no matter whether the system be cycloidal, involute or any other form), it is easy to find that point of one tooth that will come in contact with a given point of the other tooth. For instance, the point *d* (Fig. 8) of the tooth *A* will come in

contact with the other tooth, *B*, the moment when, during its circular motion, it passes the "path" at *b*, and it is easy to find the point *e* of the tooth *B* which, in course of its motion, will likewise pass through the "path" at *b*. Of these two corresponding points, *d* and *e*, the for-

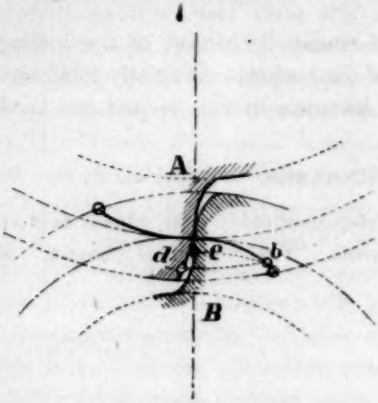

Fig. 8.

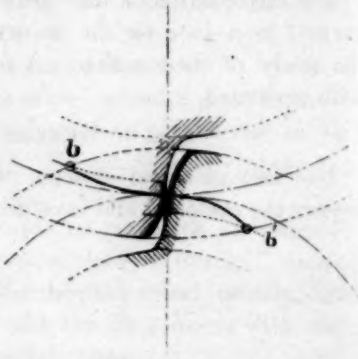

Fig. 9.

mer (of the *face* of the tooth *A*) has a greater distance from the pitch circle than the latter, of the *flank* of the tooth *B*. The fact is that all points of the face, from the pitch-circle to the point, will successively come in operation, while only a portion of the flank is made use of. The lowest useful point of the flank is that which comes in contact with the farthest end of the face of the gearing tooth, and can easily be found, as shown before. Thus, in Fig. 9, those portions of the teeth that come in actual working contact are marked by heavy lines. In the same figure, the points *b* and *b'* limit the length of the "path of contact."

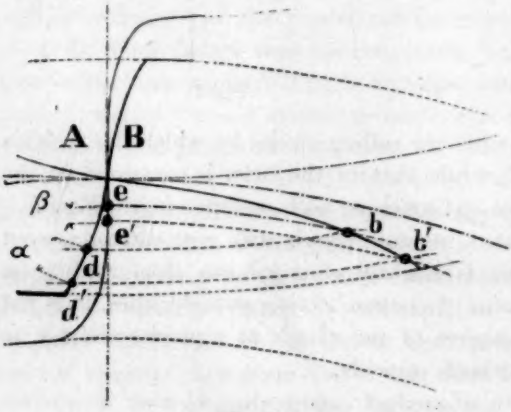

Fig. 10.

Considering a single gear wheel, the length of the outside branch of

the "path of contact" is limited by its egress from the circle circumscribing the extreme points of the teeth; the limit of the inside branch, however, remains undetermined until another wheel is brought into gear. The limited outside branch of that second wheel, in coinciding with the inside branch of the first one, determines the latter's limit for that particular couple. The inside branch is short when the mate is a small wheel, it is longer for larger wheels and racks, and assumes a still greater length when the mate becomes an inverted gear wheel. The number of teeth that are in gear at the same time depends on the length of the "path of contact."

Clearing Curves.

The lower limit or root of the useful portion of the flank is not constant for any particular gear wheel but depends on the size of the mate, and the space is extended below the root for the sole purpose of making room for the entering tooth of the mating gear. For any particular mate, the form below the root should be determined by the space needed for the motion of the entering tooth; however, since practice requires that there should be a clearance, it is proper to assume that the tooth of the mate be long enough to touch the bottom of the space, and after describing the space which this tooth requires, shorten the tooth again to the original height. In this way a strengthening fillet will be formed at the base of the tooth, which is the greater the smaller the gearing mate is. But if the wheel belongs to a set, and may be used with any size mate, it is advisable to make the fillet as small as the rack requires, and this is just what the above-described odontograph accomplishes.

Wear of Gear Wheels.

The investigation relating to the probable wear, and the liability of a consequent getting out of shape, can likewise be made with ease. While the point of contact travels from b to b' (Fig. 10), the portion $e\,e'$ of the tooth B will come in contact with the portion $d\,d'$ of the tooth A. At the beginning the points e and d are bearing, and finally the point e' will meet the point d'. The operation is partially a rolling and partially a slipping one. Denoting the lengths $d\,d'$ with α, and $e\,e'$ with β, the slip will amount to the difference $\alpha - \beta$. Assuming the pressure between the teeth to be uniform, the wear on each tooth is likely to be proportional to the slip. The wear on the tooth

A, however, will be distributed over the space $d\,d' = \alpha$, while that of the tooth B is confined to the less space $e\,e' = \beta$; hence the average depth of wear on the space $d\,d'$ is expressed by the ratio $\frac{\alpha - \beta}{\alpha}$ against that on the space $e\,e'$ at the ratio of $\frac{\alpha - \beta}{\beta}$. Thus, by dividing the "path of contact" in a number of integral portions, a diagram of the relative depth of wear can be constructed. In Fig. 11 such diagrams are represented in case of a rack gearing into a pinion of 27 teeth, both for cycloidal and involute teeth. A glance will show that cycloidal gears are far superior to involute teeth in this respect, as on the former the tendency is to wear exactly uniform, at least on either side of the pitch line, though the wear is not the same on both sides.

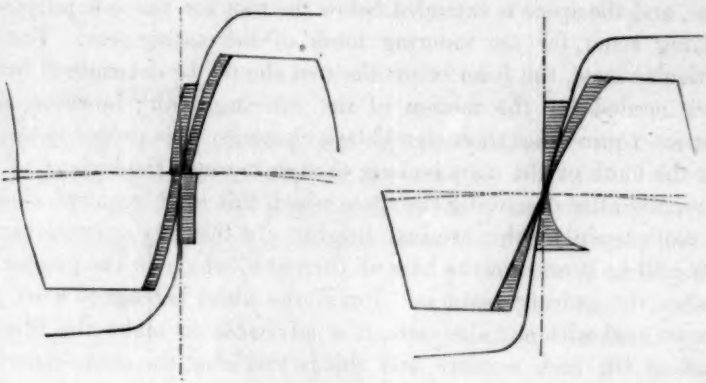

Fig. 11.

On involute teeth, there being no tendency to wear on the pitch line, a more rapid wearing out of shape will follow. The difference is attributable to the fact that the one form has a radial element at the pitch line while the other has not; for the slip being infinitely small at that point, the wear receives a definite depth only if the travel of the point of contact in relation to the curve of the tooth is infinitely slow at the same moment, giving this point, as it were, more *time* to wear, and this can only happen if the corresponding element of the tooth-form is radial. Moreover, in cycloidal wheels, the proportion of α and β is equal to the proportion of the paths of the centres of the rolling circles while describing those portions, which being constant on

each side of the centre line for any particular couple, will account for the uniform wear of cycloidal gears on each face.

Of course the diagrams, Fig. 11, must not be understood as representing the actual shape of the teeth after wear has taken place, for after the least perceptible wear the teeth will no longer be correct, and the condition will be changed so that the high points will wear more rapidly. Both diagrams, however, indicate a tendency of greater wear at the flank of the teeth.

Selection of Form.

If the form of the teeth of the original rack (or wheel) is adopted at random, it may happen that the teeth of pinions evolved from this rack become thinner below the pitch-circle than if the flanks were

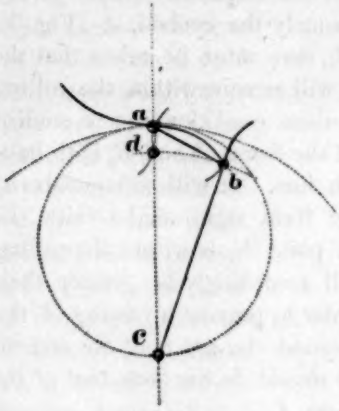

Fig. 12.

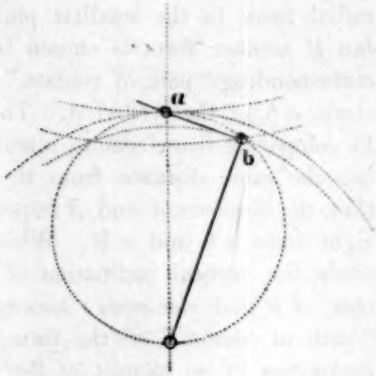

Fig. 13.

radial, or the point of the rack-tooth, in emerging from the gearing, may cut into the flank of the tooth. This can only happen if any element of the flank (*d*, Fig. 12) becomes more convergent towards the centre-line of the tooth than the radius vector of that element, or (revolving the element in question into the "path of contact," *b*) if the angle *a b c* is less than 90°. This danger increases as the diameter of the wheel is lessened or the centre, *c*, moved towards the point *a*; hence the reduction of the pinion is *limited* by the form adopted for the original tooth. For the cycloidal form, the smallest pinion admissible has a radius equal to the diameter of the rolling circle when the above-mentioned angle is equal to 90° for all points of the inner

branch of the "path of contact" and all elements of the flank are radial. For other than cycloidal forms, the "path of contact" must remain within this circle (Fig. 12) in order that the said angle for no portion of the "path" should be less than 90°. In the case of involute teeth, where the "path of contact" is represented by the line $a\ b$ (Fig. 13), the used portion of the "path" must never extend beyond the point b (which, by the way, is the point of contact of the rolling line with the evolute circle), or, in other words, the point b must never be located within the outside line or circle of the mating rack or wheel.

In making the template of an odontograph, the question is pertinent: What is the condition that must be complied with to prevent an undercutting of a given smallest pinion?

That form is undoubtedly the limit in this respect which produces a radial flank in the smallest pinion, namely the cycloid, A (Fig. 3), but if another form is chosen (say B), care must be taken that the corresponding "path of contact," $a\ b'$, will remain within the rolling circle, $a\ b$, of the cycloid A. The requisite condition can be studied by comparing two elements, α and β, of the forms A and B, both having the same distance from the pitch line. It will be remembered that the elements α and β respectively form right angles with the right lines $a\ b$ and $a\ b'$. When the point b' is within the rolling circle, the vertical inclination of β will accordingly be greater than that of α and *vice versa;* hence, in order to prevent a passing of the "path of contact" of the form B beyond the arc $a\ b$, *the vertical inclination of no element of that form should be less than that of the corresponding element of the cycloidal form* A.

Distinction Between Driving and Driven Gear.

Some mechanics, especially watchmakers, make it a practice to make the teeth of the driving wheel higher above the pitch line than those of the driven wheel. An unequal effect of friction, affecting the consequent loss of power, can be the only reason to which this practice may be assigned, and the problem may be reduced to this question: If the teeth of one pair of gear wheels are somewhat too long, will it be most advantageous to shorten the teeth of both wheels uniformly or not? Let Fig. 14 represent two such gear wheels, with their "path of contact" $b\ a\ b'$, the upper wheel, A, to be the driver. But for the friction on the face of the teeth, the transmission of force

would always be at right angles to the elements in contact and, consequently, would always pass through the point of pitch contact, *a*. Owing to friction, however, this line of force is deflected by the angle of friction. So, for instance, at the first point of contact, *b*, the line of force is *b c* (the angle *a b c* being that of friction between the teeth). The proportion of the momenta of forces is as the distances of the centres *A* and *B* from this line, or as *A c* to *B c* (owing to similar triangles), against the proportion *A a* to *B a*, if there were no friction between the teeth. The distance *a c* represents, as it were, the ratio of loss by friction while the teeth are in contact at *b*. For the last point of contact, *b'*, the line of force is *b' c'* (angle *a b' c'* = angle *a b c*), the proportion of the momenta of forces *A c'* to *B c'*, and the ratio of loss by friction is *a c'*, which is less than *a c*. The friction appears thus more unfavorable at *b* than it does at *b'*, and a reduction of the "path of contact" should be effected on the former end. If this reduction is carried to a point *b''*, for which the angle *c' b'' a* equals the angle *c' b' a* (the angle of friction), the effect of friction at that point *b''* will be no more unfavorable than it is at *b'*. The corresponding reduction of the height of teeth of the driven wheel is furnished by the point *b''*.

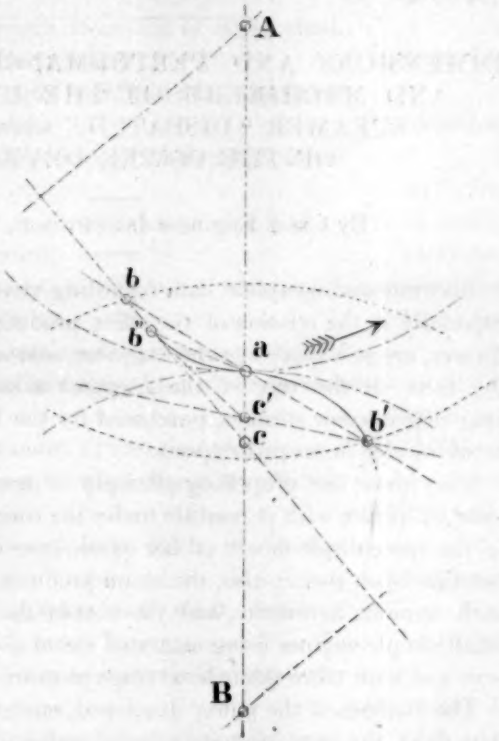

Fig. 14.

According to this, if in any special case the indicated correction is desired, the initial and terminal points, *b* and *b'*, of the "path of con-

tact" should be mutually so located that *the lines b c and b′ c′ forming with the lines a b and a b′, on the side of the driven wheel, angles equal to the angle of friction of the teeth in contact, should both intersect the line of centres, A B, in the same point.*

DIMENSIONS AND PERFORMANCE OF THE HULL AND MACHINERY OF THE UNITED STATES STEAMER "DISPATCH," WITH ANALYSES OF THE POWER DEVELOPED.

By Chief Engineer ISHERWOOD, U. S. Navy.

Accurate and complete data regarding vessels and their machinery, especially in the relation of the effect produced by the latter upon the former, are so valuable to the engineer, and so scarce, that the following facts in the case of the *Dispatch* a merchant yacht-built and brig-rigged screw steamer, purchased for the United States Navy, will be of service in several respects.

They show the propelling efficiency of her screw, and the development of power with it possible under the conditions of the vessel, and of the space displacement of her pistons per stroke with the mean net pressure upon them; also, the steam producing capacity of the boilers with common anthracite, and the cost of the power in fuel given by small simple engines using saturated steam above medium initial pressure and with more than the average measure of expansion.

The analyses of the power developed, rendered possible by the mean data from the very large number of indicator diagrams taken, show in what direction and to what extent it was expended, determine the resistance of the vessel at the experimental speeds, and ascertain its kind, and explain the cause of the inferior economic effect produced by the coal in proportion to power developed.

HULL.

The hull is of wood, coppered, and modeled for a yacht with much dead rise at the greatest transverse section. In addition to the proper central keel there is, on each side, a bilge keel, 50 feet long, the centre of which, transversely to the hull, is 9 feet 2 inches from the centre of the central keel. Each bilge keel is in cross section 25 inches wide

on top, tapering to 9¼ inches wide on bottom, and 20 inches deep.

The following are the principal dimensions of the hull:

Length from forward edge of rabbet of stem to after side of body of sternpost,	174 feet.
Extreme breadth,	25·50 feet.
Depth at centre of length from top of deck plank to lower edge of rabbet of keel,	15·33 feet.
Depth at centre of length from water line to lower edge of rabbet of keel,	10·25 feet.
Depth of keel at centre of length below the lower edge of its rabbet,	0·75 foot.
Breadth of keel,	1·00 foot.
Draught of water forward,	11·17 feet.
Draught of water aft,	12·83 feet.
Mean draught of water,	12·00 feet.
Area of the greatest immersed transverse section to 12 feet draught, exclusive of projected cross area of bilge keels,	186·58 sq. ft.
Area of the water section at 12 feet draught,	3163·34 sq. ft.
Displacement, exclusive of bilge keels, at 12 feet draught,	19328·64 cu. ft.
Displacement, exclusive of bilge keels, at 12 feet draught,	552·25 tons.
Centre of gravity of displacement abaft centre of length of water line,	4·45 feet.
Centre of gravity of displacement below the water line,	7·345 feet.
Displacement per inch of draught at 12 feet draught,	7·5318 tons
External immersed, or wetted, surface of the hull, exclusive of bilge keels, from bottom of central keel to 12 feet draught of water,	5100·00 sq. ft.
Surface of the two bilge keels,	416·00 sq. ft.
Total immersed, or wetted, surface,	5516·00 sq. ft.
Ratio of length to breadth,	6·8235
Ratio of greatest immersed transverse section to its circumscribing parallelogram,	0·7138
Ratio of water section to its circumscribing parallelogram,	0·7129

Ratio of displacement to its circumscribing parallelopipedon,	0·4250
Ratio of displacement to a solid having for base the greatest immersed transverse section, and, for length, the length of the hull,	0·5954

Engines.

There are two vertical, direct acting, simple engines, connected at right angles upon the same crank shaft. Each cylinder has, in addition to its main slide valve with a Stephenson link reversing gear, an independent adjustable slide cut-off valve. There is no exhaust lead, and the steam cushioning commences when the pistons are at 0·1667 of the end of their stroke. There is one tubular surface condenser, with the exhaust steam on the outside of the tubes, and the refrigerating water within them. The tubes are in two groups, one above the other, and the refrigerating water passes first through the tubes of the lower group, returning through those of the upper group. There are two vertical, single acting air pumps, and two single acting feed pumps. An air pump and a feed pump are worked from a lever which receives its motion from the crosshead of each engine. The refrigerating water is driven through the condenser by a centrifugal pump. The case of the pump is 46 inches in diameter over all, and 7 inches in width. The fans are 6 inches deep radially, set on arms 18 inches long from the axis to the centre of the fan. The pump is operated by one independent steam cylinder of 12 inches diameter and 10 inches stroke of piston. The condenser, the pump and the independent cylinder are much too large in proportion to the weight of steam obtainable per hour from the boilers.

The cylinders and all the connecting steam pipes are well felted and lagged, but there are no steam jackets. The following are the principal dimensions of the engines:

Number of cylinders,	2.
Diameter of one cylinder,	33⅛ inches.
Diameter of the other cylinder,	34¼ inches.
Diameter of the piston rods (one to each cylinder),	3⅝ inches.
Aggregate net area of the pistons (exclusive of rods),	1719·7804 sq. in.
Stroke of the pistons,	2·75 feet.

Aggregate space displacement of the pistons per stroke,	32·84303 cu. ft.
Aggregate space in the clearances and steam passages of both cylinders at one end,	2·28917 cu. ft.
Per centum of the space displacement of the pistons per stroke, in the clearances and steam passages,	6·97
Number of tubes (brass) in condenser,	1294.
Outside diameter of condenser tubes,	$\frac{3}{4}$ inch.
Length of condenser tubes,	55 inches.
Aggregate condensing surface, measured on outside of tubes,	1164·5 sq. ft.
Number of air pumps (single acting),	2.
Diameter of air pumps,	18 inches.
Stroke of air pump pistons,	16 inches.
Aggregate space displacement of air pump pistons per stroke,	4·7123 cu. ft.
Number of feed pumps (single acting),	2.
Diameter of feed pumps,	$3\frac{5}{16}$ inches.
Stroke of feed pump plungers,	16 inches.
Aggregate space displacement of feed pump plungers per stroke,	0·1596 cu. ft.

Boilers.

There are two cylindrical steel boilers, placed opposite each other, with an athwartship fire room between them. The boilers discharge their gases of combustion into one chimney, whose axis is directly above the centre of the fire room. The steam from both boilers is delivered into an independent annular steam drum, surrounding the lower portion of the chimney, and by an arrangement of three stop valves this drum can be shut off at will, and the steam carried directly from the steam room of the boilers to the engines. No occasion, however, has ever arisen for thus excluding the steam from the drum. The boilers and drum were well felted and lagged.

The boiler shells were 11 feet in diameter, and 8 feet 8 inches in length, exclusive of the front connection projecting over the fire room. The back lower angle was beveled to a height of 2 feet $7\frac{1}{2}$ inches in a horizontal distance of $18\frac{3}{4}$ inches. The cylindrical portion of the shell was $\frac{11}{16}$ of an inch thick, and its seams were planed, butt-jointed

and covered with double longitudinal straps $\frac{9}{16}$ inch thick. The flat heads of the shells were $\frac{1}{2}$ inch thick; their seams were planed, butt-jointed and covered with single straps $\frac{5}{8}$ inch thick. All seams were double riveted and caulked. The gussets and stay plates were riveted to cylindrical shell and flat heads by angle iron $2\frac{1}{2}$ by $2\frac{1}{2}$ inches. The lower part of the front heads was $\frac{3}{4}$ inch thick; the back tube plate was $\frac{9}{16}$ of an inch thick; the gusset plates were $\frac{1}{2}$ inch thick; the stay plates were $\frac{3}{4}$ of an inch thick, and the stay rods in the steam room were $1\frac{1}{2}$ inches in diameter, spaced 12 inches between centres. The rivets for the cylindrical shell were $\frac{7}{8}$ inch in diameter, with 3 inches pitch; those for the flat heads were $\frac{7}{8}$ inch in diameter, with $2\frac{7}{8}$ inches pitch, and those for the connections were $\frac{3}{4}$ inch in diameter, with $1\frac{7}{8}$ inches pitch.

Each boiler contained three cylindrical furnaces of 32 inches interior diameter and 6 feet $5\frac{5}{8}$ inches extreme length. The grate surface in each furnace averaged 2·6144 feet wide and 6 feet $4\frac{1}{2}$ inches long, making $16\frac{3}{8}$ square feet. Each furnace was in three sections, separated by stiffening rings $\frac{1}{2}$ inch thick and $37\frac{3}{4}$ inches outside diameter. Each section was composed of a single plate $\frac{7}{16}$ inch thick, with a planed seam, butted and secured by an inside welt. Each furnace had a cast iron front, with an opening of 12 by 18 inches for the door. The horizontal distance between the centres of the furnaces, transversely, was $34\frac{9}{16}$ inches. The least water space between the furnaces and boiler shell was $2\frac{7}{8}$ inches, and between the furnaces $5\frac{3}{4}$ inches. Manholes were made in all the spandrels above and below the furnaces.

Each boiler has a single back connection built in it, which connection is divided into three compartments by iron plates bolted in, so that each furnace has an independent back connection. The width of the connection, lengthwise the boiler, is $20\frac{3}{8}$ inches in the clear; its top is a quadrantal arc of 16 inches radius, and a flat horizontal space of $4\frac{3}{8}$ inches; its back is flat, and separated from the back of the boiler by a flat water space 6 inches wide, including thicknesses of metal. The sides of the back connection are concentric with the cylindrical shell of the boiler, and separated from it by a water space 6 inches wide, including thicknesses of metal. The flat water spaces have socket bolts at intervals of 7 inches between centres. The bottom of the connection contains the brick bridge walls, 6 inches high above the top of the grate bars, extending clear across the connection and supported on a cast iron base.

The tubes are horizontal fire tubes, returned from the back connection above the furnaces to the uptake, and they are arranged in two groups of ninety-five each. Each tube is of brass, seamless, 3 inches in outside diameter, 2·8 inches in inside diameter and 6 feet $4\frac{1}{16}$ inches long in the clear of the tube plates. The tubes are in eight rows vertically and twenty-four rows horizontally, the two outer tubes of the upper row being omitted. The distance between the centres of the tubes vertically is 4 inches, and horizontally $4\frac{3}{8}$ inches. The total height occupied by the tubes, from the bottom of the tubes of the lower row to the top of the tubes of the upper row, is 35 inches. The vertical water space between the two groups of tubes is 12 inches wide in the clear.

The uptake is of sheet iron, lined with brick and bolted to the front of the boiler above the level of the furnaces.

The following are the principal dimensions of the boilers:

Number of boilers,	2.
Diameter of boiler,	11 feet.
Length of boiler, exclusive of uptake,	8 feet 8 inches.
Number of furnaces in each boiler,	3.
Interior diameter of furnaces,	2 feet 8 inches.
Length of grate surface,	6 feet $4\frac{1}{2}$ inches.
Mean breadth of grate surface,	2·6144 feet.
Aggregate area of grate in both boilers,	100 square feet.
Number of tubes in each boiler,	190.
Outside diameter of tubes,	3 inches.
Inside diameter of tubes,	2·8 inches.
Length of tubes between the tube plates,	6·390625 feet.
Diameter of the chimney,	4 feet 6 inches.
Height of the chimney above the level of the grates,	43 feet 6 inches.
Aggregate cross area over bridge walls for draught in both boilers,	16·5000 sq. ft.
Aggregate cross area through tubes for draught in both boilers,	16·2490 sq. ft.
Cross area of chimney,	15·9042 sq. ft.
Aggregate area of heating surface in the furnaces of both boilers,	174·1018 sq. ft.
Aggregate area of heating surface in the back connections of both boilers,	212·1726 sq. ft.

Aggregate area of heating surface in the tubes of both boilers, calculated for inside diameter,	1780·1256 sq. ft.
Aggregate area of heating surface in the uptakes of both boilers,	47·6000 sq. ft.
Total area of heating surface in both boilers,	2214·0000 sq. ft.
Ratio of the grate surface to the cross area above the bridge walls,	6·0606
Ratio of the grate surface to the cross area through the tubes,	6·1542
Ratio of the grate surface to the cross area of the chimney,	6·2876
Ratio of the heating surface to the grate surface,	22·1400
Exterior diameter of the steam drum,	6 feet 6 inches.
Interior diameter of the steam drum,	4 feet 6 inches.
Height of the steam drum,	6 feet 3 inches.
Steam superheating surface in the steam drum,	88·3575 sq. ft.
Greatest height of steam room in boilers,	3 feet.
Aggregate steam room in shells of both boilers,	360 cubic feet.
Steam room in the steam drum alone,	108 cubic feet.
Total steam room,	468 cubic feet.

Screw.

There is one true screw, with the blades curved backwards on a radius of 37 feet for the forward edge. The screw is bronze, and of uniform length from hub to periphery.

Diameter of the screw,	11·10 feet.
Diameter of the hub,	1·75 feet.
Pitch (by measurement after screw was cast),	19·90 feet.
Length of the screw in the direction of its axis,	1·4583 feet.
Number of blades,	4.
Fraction used of the pitch,	0·2931
Projected area of the blades on a plane at right angles to axis,	27·6611 sq. ft.
Helicoidal area of the blades,	37·8914 sq. ft.
Weight of the screw,	4520 pounds.
Thickness of the blades of fillet of hub,	4·4375 inches.
Thickness of the blades at periphery,	0·375 inch.

TRIAL OF THE "DISPATCH" MADE IN CHESAPEAKE BAY BY A BOARD OF U. S. NAVAL ENGINEERS TO ASCERTAIN HER MAXIMUM SPEED, POWER AND CONSUMPTION OF COAL.

The following trial was made in Chesapeake Bay, by a Board of United States Naval Engineers, with the *Dispatch* at her deep load draught of water, to ascertain the maximum speed which could be permanently maintained in smooth water and uninfluenced by wind or current, burning anthracite in the condition in which it was delivered by the contractors, and with only the regular firemen of the engineer department of the vessel; also, to ascertain the power required for this speed, and the consumption of coal to produce it.

The trial continued nine consecutive hours, during which the vessel was run four and a half hours in a straight line in one direction, and then four and half hours in the opposite direction, in order to neutralize the effects of wind and current. The water was smooth. The speed was noted by a taffrail log, by a patent log, and by the shore marks according to the Coast Survey chart. The wind was a gentle breeze, alternately on the port bow and starboard quarter.

Indicator diagrams were taken from each end of each cylinder every fifteen minutes, at which times there were noted in the appropriate columns of a tabular record, or log, the steam pressure in the boiler, the vacuum in the condenser, the height of the barometer, the number on the counter, and the temperatures of the air on deck and in the engine room, of the injection water, of the discharge water, and of the feed water in the hot well.

The throttle valve was kept wide open throughout, and the full throw of the Stephenson links were used.

The trial was begun with fresh, clean fires, of noted thickness, and ended with them in the same condition as nearly as could be judged. All the anthracite consumed and its refuse were weighed. The pressure of the steam and the height of the water in the boilers were left at the close of the trial the same as at its commencement.

The following are the mean results from all the observed data:

Date of the experiment, ...		January 14, 1880.
VESSEL.		
Vessel's draught of water, in feet and inches:	forward, .	11·6
	mean, .	12·2
	aft, .	12·10
Vessel's greatest immersed transverse section in square feet, including projection of bilge keels, . .		195·552

Vessel's displacement, in tons, including bilge keels,	574·06
Vessel's external immersed or wetted surface, in square feet, including surface of bilge keels,	5576·00

ENGINES.

Steam pressure in boilers, in pounds per square inch above the atmosphere,	52.
Position of the throttle valve,	Wide open.
Fraction of the stroke of the pistons completed when the steam was cut off,	0·1166
Number of times the steam was expanded,	5·7418
Fraction of the back stroke of the piston completed when the steam was cushioned,	0·8333
Vacuum in the condenser, in inches of mercury,	25·50
Pressure in the condenser, in pounds per square inch above zero,	2·076
Height of the barometer,	29·73
Number of revolutions made per minute by the circulating pump,	150.
Number of double strokes made per minute by the pistons,	64·5333

TEMPERATURES.

Temperature, in degrees Fahrenheit, of the air on deck,	44·0
Temperature, in degrees Fahrenheit, of the injection water,	34·5
Temperature, in degrees Fahrenheit, of the discharge water,	73·0
Temperature, in degrees Fahrenheit, of the feed water,	100·0
Temperature, in degrees Fahrenheit, of the air in the engine room,	82·0

SPEED.

Speed of the vessel per hour, in geographical miles of 6086 feet,	10·75
Slip of the screw, in per centum of its speed,	15·0914

RATE OF COMBUSTION.

Pounds of anthracite consumed per hour,	1550·
Pounds of refuse per hour from the anthracite, in ash, clinker, etc.,	310·
Pounds of combustible or gasifiable portion of the anthracite consumed per hour,	1240·
Per centum of the anthracite in refuse of ash, clinker, etc.,	20·
Pounds of anthracite consumed per hour per square foot of grate surface,	15·50
Pounds of anthracite consumed per hour per square foot of heating surface,	0·7001

Pounds of combustible consumed per hour per square foot of grate surface,	12·40
Pounds of combustible consumed per hour per square foot of heating surface,	0·5601

STEAM PRESSURES IN CYLINDERS, PER INDICATOR.

Pressure on pistons in pounds per square inch above zero, at commencement of their stroke,	55·90
Pressure on pistons in pounds per square inch above zero, at point of cutting off the steam,	53·85
Pressure on pistons in pounds per square inch above zero, at end of their stroke,	14·23
Mean back pressure against pistons, including cushioning, in pounds per square inch above zero,	6·63
Mean back pressure against pistons for the portion of their stroke during which the steam was not cushioned, in pounds per square inch above zero,	5·90
Back pressure against pistons, in pounds per square inch above zero, at the point where the cushioning of the steam began,	5·39
Indicated pressure on the pistons, in pounds per square inch,	21·776
Net pressure on the pistons, in pounds per square inch,	20·026
Total pressure (exclusive of cushioning) on the pistons, in pounds per square inch, reduced in the ratio of the stroke of the piston to the fraction of the stroke completed when the cushioning began,	26·693

HORSES-POWER.

Indicated horses-power developed by the engines,	402·7950
Net horses-power developed by the engines,	370·4249
Total horses-power developed by the engines,	493·7458
Total horses-power developed from the expanded steam alone,	406·8089

ECONOMIC RESULTS.

Pounds of anthracite consumed per hour per indicated horse-power,	3·8481
Pounds of anthracite consumed per hour per net horse-power,	4·1844
Pounds of anthracite consumed per hour per total horse-power,	3·1393
Pounds of combustible consumed per hour per indicated horse-power,	3·0785
Pounds of combustible consumed per hour per net horse-power,	3·3475
Pounds of combustible consumed per hour per total horse-power,	2·5114

WEIGHT OF STEAM ACCOUNTED FOR BY THE INDICATOR.

Pounds of steam present per hour in the cylinders at the point of cutting off, calculated from the pressure there,	5355·6091
Pounds of steam present per hour in the cylinders at the end of the stroke of the pistons, calculated from the pressure there,	9149·5487
Pounds of steam condensed per hour in the cylinders to furnish the heat transmuted into the total horses-power developed from the expanded steam alone,	1078·8964
Sum of the two immediately preceding quantities,	10228·4451

DISTRIBUTION OF THE POWER DURING THE ABOVE PERFORMANCE.

The following distribution of the average indicated power developed by the engines during the above performance, is made on the supposition: 1st. That the power required to work the engines *per se*, or unloaded, is what was due to a pressure of $1\frac{3}{4}$ pounds per square inch of the piston. 2d. The subtraction of the power, thus calculated, from the indicated power, leaves the net power, of which $7\frac{1}{2}$ per centum is taken for the power absorbed by the friction of the load. 3d. The power expended in overcoming the resistance of the water to the surface of the screw blades is calculated on the data that each square foot of this surface moving in its helical path, with a velocity of 10 feet per second, experiences a resistance of 0·45 pound, which resistance for other speeds varies as the square of the speed. 4th. Deducting the sum of the powers absorbed by the friction of the load and expended in overcoming the resistance of the water to the surface of the screw blades, from the net power, leaves a remainder which is expended in the slip of the screw and in the propulsion of the hull. Dividing this remainder in the proportion of the speed of the slip and the speed of the vessel, there is obtained for each the power expended on it.

	Horses-Power.	Per Centum of the Net Horses-Power.
Indicated power developed by the engines,	402·7950	
Power expended in working the engines, *per se*,	32·3701	
Net power applied to the crankpins,	370·4249	or 100·0000
Power absorbed by the friction of the load,	27·7819	or 7·5000
Power expended in overcoming the resistance of the water to the surface of the screw blades,	25·6238	" 6·9174
Power expended in the slip of the screw,	47·8426	" 12·9156
Power expended in the propulsion of the vessel,	269·1766	" 72·6670
Totals,	370·4249	" 100·0000

THRUST OF THE SCREW DURING THE ABOVE PERFORMANCE.

The thrust of the screw, as it would have been measured by a dynamometer, during the above performance, calculated from the data therein given and in the distribution of the power, is as follows:

The horses-power expended in the propulsion of the vessel according to the distribution of the power, being 269·1766, is equal to (269·1766 × 33000 =) 8882827·8 foot-pounds of work per minute; and the speed of the vessel being 10·75 geographical miles per hour, is equal to $\left(\frac{10{\cdot}75 \times 6086}{60} = \right)$ 1090·4083 feet per minute; hence, the resistance of the vessel at that speed, or its equivalent the thrust of the screw, is $\left(\frac{8882827{\cdot}8}{1090{\cdot}4083} = \right)$ 8146·3315 pounds.

DETERMINATION OF THE POWER EXPENDED IN OVERCOMING THE RESISTANCE OF THE WATER TO THE IMMERSED EXTERNAL OR WETTED SURFACE OF THE HULL.

Taking the resistance of the water to one square foot of rolled copper surface, moving in it with the velocity of 10 feet per second, to be 0·45 pound; and at other velocities to be this quantity modified in the ratio of their squares to the square of 10; and deducing from the speed of the vessel the mean speed of its immersed surface due to the inclination of its horizontal water lines to its longitudinal central plane, there results for that speed 18 feet per second; and, consequently, a surface resistance of ($10^2 : 0{\cdot}45 :: 18^2 :$) 1·458 pounds per square foot moving with that velocity.

As the immersed external or wetted surface of the vessel during the above performance was 5576 square feet, the power expended in overcoming its resistance was $\left(\frac{5576 \times 1{\cdot}458 \times 18 \times 60}{33000} = \right)$ 266·0664 horses, which are substantially the same as the 269·1766 horses-power expended in the propulsion of the vessel, according to the preceding "distribution of the power" developed by the engines. In other words, the entire resistance of the vessel was sensibly that of the water to its immersed external surface; and, consequently, no engine power was expended in overcoming the resistance of the water to displacement by the progress of the vessel. That is to say, the difference between the power exerted by the fore body of the vessel in raising

the displaced water from the centre of gravity of the greatest immersed transverse section of the vessel to the general water level, and the power exerted upon the after body of the vessel in the direction of its motion by the ascending column of water caused by the forward movement of the vessel, were sensibly equal.

In the *Dispatch*, therefore, as in many other excessively sharp vessels, with long after bodies relatively to combined draught of water and speed, nearly or quite the whole of the engine power applied to the propulsion of the vessel is expended in overcoming the resistance of the water to its immersed external surface; the power exerted by its fore body in displacing water being nearly or wholly recovered by the power exerted propulsively on its after body by the column of water rising vertically to fill the void left by the passage of the vessel.

Average Performance under the Conditions of Ordinary Practice, in Smooth Water Uninfluenced by Wind or Current.

The following is the average performance of the *Dispatch*, in the Potomac River and Chesapeake Bay, under the conditions of ordinary practice, and embracing the whole of her steaming from November 8, 1880 to March 30, 1881, the water being smooth and the breeze gentle abeam. During this steaming there were in the bunkers, on an average, 90 tons of coal, the full quantity being 130 tons. The aggregate time of steaming was 358 hours; the fuel was anthracite consumed by natural draught. The vessel's draught of water during this time averaged 11 feet 2 inches forward and 12 feet 10 inches aft. A regular tabular log was kept, indicator diagrams were taken at intervals, and all the quantities were accurately ascertained.

Hull.

Vessel's mean draught of water in feet, . . .	12·
Vessel's greatest immersed transverse section, in square feet, including projection of bilge keels, . . .	191·3
Vessel's displacement, in tons, including bilge keels, .	559·
Vessel's external immersed or wetted surface, in square feet, including surface of bilge keels, . . .	5516·

Engines.

Steam pressure in boilers, in pounds per square inch above the atmosphere, ...	49·3
Position of the throttle valve, . . .	⅞ open.

Fraction of the stroke of the pistons completed when the steam was cut off,	0·112
Number of times the steam was expanded,	5·8872
Vacuum in the condenser, in inches of mercury,	25·50
Pressure in the condenser, in pounds per square inch above zero,	2·45
Barometer, in inches of mercury,	30·
Number of revolutions made per minute by the circulating pump,	125·
Number of double strokes made per minute by the pistons,	59·484

RATE OF COMBUSTION.

Pounds of anthracite consumed per hour,	1253·50
Pounds of refuse per hour from the anthracite, in ash, clinker, etc.,	269·50
Pounds of combustible or gasifiable portion of the anthracite consumed per hour,	984·00
Per centum of the anthracite in refuse of ash, clinker, etc.,	21·50
Pounds of anthracite consumed per hour per square foot of grate surface,	12·535
Pounds of anthracite consumed per hour per square foot of heating surface,	0·5662
Pounds of combustible consumed per hour per square foot of grate surface,	9·840
Pounds of combustible consumed per hour per square foot of heating surface,	0.4444

TEMPERATURES.

Temperatures, in degrees Fahrenheit, of the air on deck,	62·5
Temperature, in degrees Fahrenheit, of the air in the engine room,	91·0
Temperature, in degrees Fahrenheit, of the injection or refrigerating water,	63·5
Temperature, in degrees Fahrenheit, of the discharge water,	85·0
Temperature, in degrees Fahrenheit, of the feed water.	107·9

SPEED.

Speed of the vessel per hour, in geographical miles of 6086 feet,	9·9195
Slip of the screw, in per centum of its speed,	15·00

STEAM PRESSURES IN CYLINDERS, PER INDICATOR.

Pressure on pistons, in pounds per square inch above zero, at commencement of their stroke,	48·60
Pressure on pistons, in pounds per square inch above zero, at point of cutting off the steam,	46·80
Pressure on pistons, in pounds per square inch above zero, at end of their stroke,	11·15
Mean back pressure against pistons, including cushioning, in pounds per square inch above zero,	5·90

Mean back pressure against pistons, for the portion of their stroke during which the steam was not cushioned, in pounds per square inch above zero,	5·28
Back pressure against pistons, in pounds per square inch above zero, at the point where the cushioning of the steam began,	5·00
Indicated pressure on the pistons, in pounds per square inch,	18·434
Net pressure on the pistons, in pounds per square inch,	16·684
Total pressure (exclusive of cushioning) on the pistons, in pounds per square inch, reduced in the ratio of the stroke of the piston to the fraction of the stroke completed when the cushioning began,	22·834

HORSES-POWER.

Indicated horses-power developed by the engines,	314·2979
Net horses-power developed by the engines,	284·4605
Total horses-power developed by the engines,	389·3174
Total horses-power developed from the expanded steam alone,	323·2320

ECONOMIC RESULTS.

Pounds of anthracite consumed per hour per indicated horse-power,	3·9882
Pounds of anthracite consumed per hour per net horse-power,	4·4066
Pounds of anthracite consumed per hour per total horse-power,	3·2197
Pounds of combustible consumed per hour per indicated horse-power,	3·1308
Pounds of combustible consumed per hour per net horse-power,	3·4592
Pounds of combustible consumed per hour per total horse-power,	2·5275

WEIGHT OF STEAM ACCOUNTED FOR BY INDICATOR.

Pounds of steam present per hour in the cylinders at the point of cutting off, calculated from the pressure there,	4154·6287
Pounds of steam present per hour in the cylinders at the end of the stroke of the pistons, calculated from the pressure there,	6559·1121
Pounds of steam condensed per hour in the cylinders to furnish the heat transmuted into the total horses-power developed by the expanded steam alone,	851·9174
Sum of the two immediately preceding quantities,	7411·0295

DISTRIBUTION OF THE POWER DURING THE ABOVE AVERAGE PERFORMANCE.

The following is the distribution of the power developed by the engines, calculated as precedingly described, during the above average

performance of the *Dispatch*, under the conditions of ordinary practice, in smooth water and uninfluenced by wind or current.

	Horses-Power.	Per Centum of Net Horses-Power.
Indicated power developed by the engines,	314·2979	
Power expended in working the engines, *per se*,	29·8374	
Net power applied to the crankpins,	284·4605	or 100·0000
Power absorbed by the friction of the load,	21·3345	" 7·5000
Power expended in overcoming the resistance of the water to the screw blades,	20·0675	" 7·0546
Power expended in the slip of the screw,	36·4588	" 12·8168
Power expended in the propulsion of the vessel,	206·5997	" 72·6286
Totals,	284·4605	" 100·0000

Thrust of the Screw During the Above Average Performance.

The thrust of the screw, as it would have been measured by a dynamometer, during the above average performance, calculated from the data just given, as precedingly described, is as follows:

The horses-power expended in the propulsion of the vessel, according to the above "distribution of the power," being 206·5997, is equal to ($206{\cdot}5997 \times 33000 =$) 6817790·1 foot-pounds of work per minute; and the speed of the vessel being 9·9195 geographical miles per hour, is equal to $\left(\frac{9{\cdot}9195 \times 6086}{60} =\right)$ 1006·16795 feet per minute; hence the resistance of the vessel at that speed, or its equivalent the thrust of the screw, is $\left(\frac{6817790{\cdot}1}{1006{\cdot}16795} =\right)$ 6775·996 pounds.

Determination of the Power Expended During the Above Average Performance, in Overcoming the Resistance of the Water to the Immersed External or Wetted Surface of the Hull.

Taking the resistance of water to one square foot of rolled copper surface, moving in it with the velocity of 10 feet per second, to be

0·45 pound; and at other velocities to be this quantity modified in the ratio of their square to the square of 10; and deducing from the speed of the vessel the mean speed of its immersed surface due to the inclination of its horizontal water lines to its longitudinal central plane, there results for that speed 16·58 feet per second, and, consequently, a surface resistance of $(10^2 : 0{\cdot}45 :: 16{\cdot}58^2 =)$ 1·237 pounds per square foot moving with that velocity.

As the immersed external or wetted surface of the vessel, during the above average performance, was 5516 square feet, the power expended in overcoming its resistance was $\left(\frac{5516 \times 1{\cdot}237 \times \overline{16{\cdot}58 \times 60}}{33000} =\right)$ 205·6912 horses. Now, according to the "distribution of the power" developed by the engines during the average performance, the power expended in the propulsion of the hull was 206·5997 horses; consequently, the entire resistance of the vessel was sensibly that of the water to its immersed external surface. This result, from data wholly independent of that given by the Board of Naval Engineers for the previous experiment, and obtained by different persons and at different times, shows both the accuracy of the observations and of the constants, as well as the correctness of the method and the deduction.

The Economic Result.

The cost of the power developed by the engines in fuel appears very great, reaching to nearly four pounds of anthracite consumed per hour per indicated horse-power, the refuse from the coal being a little over one-fifth of the latter; and the cause will be found, as might be expected, in the enormous cylinder refrigeration due to the work of expansion by steam of high initial pressure largely expanding, the point of cutting off being a little beyond one-ninth of the stroke of the pistons from the commencement. Under these circumstances, when saturated steam is used with simple engines having cylinders of very moderate dimensions, without steam jackets, as in the *Dispatch*, the cylinder condensation is excessive and entirely defeats the economy which might be obtained from the same measure of expansion employed with superheated steam in steam-jacketed cylinders of large dimensions. In fact, saturated steam cut off at one-ninth of the stroke of the piston, in cylinders like those of the *Dispatch*, produces no greater economy than if it was used with very much less expansion.

Assuming the economic vaporization of the boilers to have been

about eight pounds of water, from the temperature of the feed, per pound of anthracite consumed, which was probably near the truth, the results from the indicator diagrams show that during about the first ninth of the stroke of the pistons, about 57½ per centum of all the steam entering the cylinders was condensed by their surfaces; including, of course, the surfaces in the steam passages up to the valves. Of course, during this one-ninth of the stroke of the pistons no power whatever was obtained from 57½ per centum of all the steam generated in the boilers. From the point of cutting off the steam to the end of the stroke of the pistons there went on a continuous re-evaporation of this water of condensation under the continuously decreasing pressure due to the continuous development of space by the moving pistons, but the steam produced by this re-evaporation pressed the pistons for only the remainder of their stroke from the point where the re-evaporation took place. The re-evaporated steam did not, probably, act through more than 45 per centum of the stroke of the pistons, and during that with a very small average measure of expansion, the expansion becoming less and less as the re-evaporation took place later and later. The intended measure of expansion due to the cutting off at one-ninth of the stroke of the pistons from the commencement thus applies to only (100·0—57·5=) 42½ per centum of the steam generated in the boilers. When the pistons reached the end of their stroke the steam supplied by the re-evaporation was sufficient to leave only 22 per centum of the quantity generated in the boilers condensed; so that a large portion of the expansion part of the indicator diagram was due to this re-evaporation. The 22 per centum of the steam generated in the boilers, which was present in the cylinders as water of condensation when the pistons arrived at the end of their stroke, were re-evaporated to the condenser under its much less pressure during their return or exhaust stroke, producing no effect upon them.

The heat for the re-evaporation in the cylinders of the water of condensation was supplied by the metal of the cylinders and by the contained heat of the water itself. The metal is first heated during the admission portion of the stroke of the piston by the entering steam which undergoes a corresponding condensation to supply the heat required; and then cooled during the expansion portion of the stroke by the continuous re-evaporation of the resulting water of condensation under the continuously decreasing pressure due to the expansion.

MECHANICAL DRAWING.

By Coleman Sellers, Jr.

A lecture delivered before the Franklin Institute, November 11th, 1881.

When Mr. John S. Clark lectured before you last summer, he told you that drawing is of three kinds: Representative, which treats of objects as they appear; Constructive, which shows how they are to be made, and Decorative, which treats of ornamenting them.

Of course it is beyond the possibilities of a single lecture to go very deeply into the consideration of any one of these co-ordinate themes, and all I hope to do this evening is to direct your attention to a few of the questions involved in the practice of the second of these arts, namely, *Constructive* Drawing. Constructive Drawing is generally of the kind we call *mechanical*, in contradistinction to *free-hand*. That is to say, in the one case we use instruments of precision to determine form and size, while in the other we depend entirely upon accuracy of eye and skill of hand for the proportion of the parts of the drawing. But this distinction is not absolutely rigid—all constructive drawings are not mechanical drawings, nor are all mechanical drawings constructive.

Drawing has been called the universal language—intelligible to all grades of civilization, irrespective of tongue or nationality. The engraved monuments of extinct races tell us their stories of bygone times and manners, and we read them more or less correctly, although we may know not a word of Assyrian, Aztec or Egyptian. The written language of the savage, as far as he has one, is a series of rude pictures and, indeed, we seldom meet minds so uneducated that they fail to recognize a picture of any familiar object.

We are told of the men of ready pencil who travel in foreign lands and make known their wants by a happy knack of off-hand sketching. There was the young man, for instance, who vainly tried to convey the idea of fried eggs to the obtuse peasant and who, having exhausted alike his vocabulary and his patience without the desired result, in sheer desperation seized paper and pencil and, by a rude sketch of a frying-pan and one of an egg, got the breakfast he wanted. Although I dare say, if the truth were known, to prevent the eggs being taken

for potatoes, he was obliged to supplement his drawing of the eggs with a portrait of the hen.

The universality of drawing, however, applies only to its representative phase. *Constructive* drawing has not the same quality—it is not universal in the sense that it conveys adequate ideas to all minds without regard to education. Representative drawing shows things as they appear, and hence appeals to all who can see. Constructive drawing proceeds upon certain known principles or *conventions*, and some knowledge of these we must have to understand drawings of this kind. Special knowledge is demanded alike of the man who makes and the man who uses the *working-drawing*, on the part of the draughtsman and on that of the artisan. The one must understand drawing, the other must understand drawings.

We do not possess an intuitive knowledge of constructive drawing; on the contrary, to many minds the simplest working drawing is merely an unintelligible maze of unrelated lines. Among artisans, the very men for whom drawings are made, we frequently find those, perhaps good workmen, who cannot receive their instructions in that form; and even among men who profess to have mechanical ideas, would-be inventors perhaps, we now and then meet those who have a perfect incapacity to explain to others with the pencil those ideas which they believe are yearning for expression. Ignorance of this kind, appearing as it so often does among men who must constantly have to do with working drawings, shows a lamentable deficiency in school and shop education.

Drawing of some kind is absolutely necessary to the useful arts: if we leave out of consideration those shapes or details which may be described in a few words, drawing becomes the only means of communication between the designer and the workman—the only method of conveying ideas of anything to be made. The simplest utensils, the most complicated machines, must be expressed graphically before they can be constructed. For the simpler forms, this drawing may be, it is true, only a sketch made by the foreman on the shop door; but it gives ideas of size and general shape which could not be expressed in words. The day has passed for these rough approximate sketches, however, and for many other equally crude makeshifts that were once common in shops. The needs of modern work demand drawings that will tell a straight story, that will express their meaning clearly and without equivocation, that are the result of a careful and system-

atic consideration of the subject shown, in all its bearings, and, furthermore, that will be a complete and accurate record of the machine when finished—a record which will enable any part to be reproduced as nearly as mechanical methods will permit.

Representative drawing considers *apparent* form and size—that is, the distance of the object drawn from the spectator is involved; and the relative size and positions of the parts, as shown in the drawing, are determined by the laws of Linear Perspective.

A perspective view—that is, a representative drawing—of a house or a locomotive as either appears, will give the best idea of the one or the other to the untechnical mind, especially if the actual colors of the natural objects be reproduced; but drawings of this kind would be of little use to the man who wishes to build a locomotive or a house. The constructive or working drawing does not consider alone the external semblance, but must dissect, as it were, the anatomy of the thing represented and show each part in its relation to every other; it must show the floors, the stairways, the doors and windows, and a multitude of other particulars in the case of the house or the various component parts of the locomotive, and it will in either case be more or less complete as it gives with greater or less minuteness these various details.

While representative drawing treats of color, of *apparent* form and *relative* size, constructive or, as it is usually termed in common parlance, mechanical drawing deals with *actual* form and *real* size.

Drawings may be as large as the objects drawn, in which case we say they are "full size," or, for convenience, they may be smaller or larger, "one-half" or "quarter size," or "double size," or any other multiple; but, in any case, all parts of the object are reduced or enlarged in the same ratio, or, as we say, to the same scale. The principles of constructive drawing are variously applied to suit different subjects, or the need of different craftsmen—architects, machinists, ship-builders, etc.; and by "mechanical drawing" to-night we will designate constructive drawing as applied to the needs of the machine shop.

Mechanical drawing represents objects as projected or thrown upon a plane surface: no account is made of distance or perspective; but the drawing appears as though its lines had been traced from the object on a transparent paper held against it. In fact it goes further, and indicates, in various ways, parts that are really invisible, and, by dotted lines and imaginary cross-sections, it displays details which perhaps

could not be seen from any standpoint from which the object could be viewed. Mechanical drawing is thus conventional from the outstart; that is, it is founded upon an understanding that certain things are to be expressed graphically in certain ways. Of these "conventions" the most important is that of projections. Descriptive Geometry, which is the science whose practical application is supposed to be in making mechanical drawings, and whose object is to "represent accurately upon plane surfaces all geometrical magnitudes as they exist in space",—Descriptive Geometry teaches us that objects are to be considered as projected upon three planes—a horizontal, a vertical, and others perpendicular to these, called side-planes.

Now, objects to be represented may be situated in either of the four *diedral* angles formed by the horizontal and vertical planes of projection; but for purposes of convenience we are told to consider all objects as being in the first angle, that is, above the horizontal in front of the vertical plane. I have here four light wooden frames, hinged together; two of them are 10 inches by 20 inches and the others are 10 inches square. These are covered with paper, and may be taken to represent portions of the planes of projection as seen in the first angle. I have here, also, a wooden model of rectangular shape, mounted on a stand. The surface of this model is diversified by certain irregularities, depressions and projections. (See Fig. 1.)

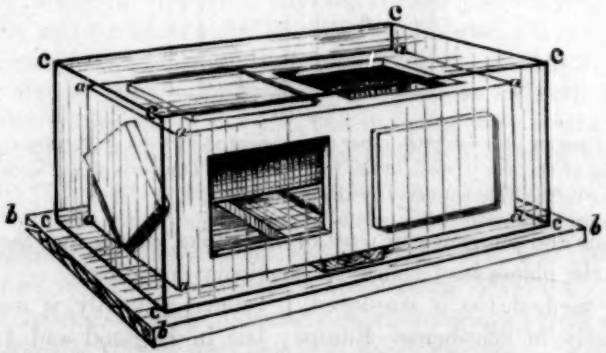

FIG. 1.—Model surrounded by glass plates, representing the *Planes of Projection*. *a*, *a*, etc., *model*; *b*, *b*, etc., *base*; *c*, *c*, etc., glass case.

I now place the model over the frame which represents the horizontal plane, and at a distance from it of one inch, and fold around it the other planes, each being one inch distant from the side of the model,

which now appears as though viewed in the first angle. Now, we are taught that this model is to be drawn by imagining every point represented in each plane by the point in which a perpendicular to the plane passing through the given point in the model would cut the plane; that is to say, a number of perpendiculars from the front of the object will form its projection upon the vertical plane, perpendiculars from the top will form upon the horizontal plane its plan, and in the same way a view or projection of the left end of the model will be formed upon the side plane on the right hand. Supposing the projections made, we proceed to reduce them to one plane by folding the side plane off to the right and the horizontal plane downwards, and then, as you see, we have a drawing of the model in which the views are arranged thus: before us we have a front elevation, below it we see the plan, and upon the right hand we have an elevation of the left hand and of the model. (Fig. 2.) This is the method usually taught

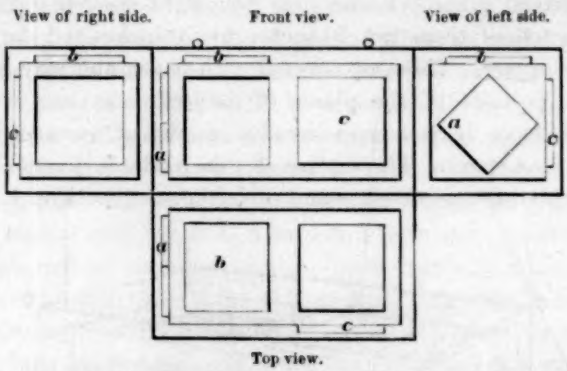

FIG. 2.—Frames covered with paper to represent the *Planes of Projection*, showing a drawing of the model made in the "1st Angle." The parts of the model are represented in the different views by the same letters, *a*, *b*, *c*, etc.

in schools and set down in most of the books, except that the revolution of the planes is of course an imaginary operation.

This method, too, is employed, I believe, generally, if not almost universally, in continental Europe; but in England and America a different system has long been in vogue, which, while quite as correct mathematically as that I have shown, has certain practical advantages which make it by far the preferable plan for use in working drawings. What is considered the practical method we may illustrate in a similar manner; but let us substitute for our paper planes corresponding

sheets of glass, hinged together, and let us arrange them differently; that is, we put the horizontal plane above the model instead of below it, and the vertical plane in front instead of behind; in the first method we in fancy looked through the model at the planes, *i. e.*, paper; we now reverse this, and look through the planes at the model, and we have simply to trace upon each plane the lines of the object which we see. (Fig. 1.) Having done this, we again unfold our

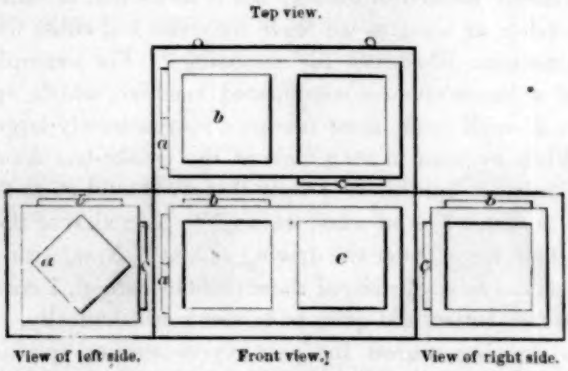

FIG. 3.—Glass case (see Fig. 1) unfolded, showing a drawing of the model made according to the "Common Sense" method. The different views of the same parts are adjacent to one another.

frame, by lifting the horizontal into the vertical and bringing out the side plane, and we have a side elevation with a plan above it, and an end elevation next the end which it represents; or, in other words, our drawing appears exactly as though we had made a cardboard model of the outside of the object, and had laid the sides down on the table so arranged that by folding them they would form a solid of the shape of the object. This, I submit, is the natural, convenient and correct disposal of these views, and I think we can the better appreciate this arrangement if we drop the misleading words, *plan* and *elevation*—terms which we have borrowed from architectural drawings. In very many mechanical drawings, especially detail-drawings, almost any side may be taken as plan or elevation with equal propriety. Perhaps we associate the idea of altitude with the term "elevation," and have an instinctive feeling that the "plan" should appear below it; but in point of fact what we call the "plan" in mechanical drawings is generally a top view, or one looking down on the object from above, and hence properly put at the top of the sheet, while the space below is

reserved for a bottom view, or one looking at the object from beneath, and such a one may be extremely important. Less confusion of ideas would result from the systematic use of the words—top view, bottom view, front and back views, and end views.

The plan recommended by the Descriptive Geometries is not bad when the object is simple; indeed, for the purpose of studying the principles of drawing scientifically, I see no reason why it is not the most convenient method to follow; but it seems that certain inconveniences develop as soon as we leave the cones and cubes with which the mathematician illustrates his reasoning.* For example, take a drawing of a locomotive—a complicated machine, which, even when reduced to a small scale, must occupy a comparatively large sheet of paper. When we want to see a view of the smoke-box door in front of the boiler, is it natural or proper that we should go to the end of the tender to find it? And when we want to see a view of the cab roof should we look for it under the driving wheels? Now, with all deference to what has been considered the scientific method, I contend that it is easier and better, and quite as correct mathematically, to put the views of a drawing nearest the part represented, or, speaking in the language of Descriptive Geometry, to draw the object in the third angle, viz., that below the horizontal plane, and behind the vertical.

The front elevation is almost always the view which carries the largest number of dimensions and shows the most parts, hence we put it in that part of the drawing where it can be most readily consulted; in the plan, or top view, we want to show the general arrangement of the parts; it usually has but few dimensions, and we easily look up to consult it; while in drawing the end views it is manifestly much easier and more mechanical to project from the right hand end of the object to an end elevation on the right hand of the board, than it is to carry all these lines over to the left hand end of your drawing board. That is, the shorter the distance between the two views of the same parts, the easier, the more convenient and more accurate are the operations of projecting with straight edge or T square. In arranging the various oblique planes which may be needed to show parts of the surface we have simply to follow the same rule—we draw the view as it would

* Further thought on this subject indicates that this assertion should be qualified, and I am now disposed to think that investigation may possibly demonstrate that the whole subject can be as well taught by abandoning the intersecting planes and substituting the "glass box" conception.

appear through a plate of glass held parallel to the surface we wish to show. Take, for example, a truncated cone (Fig. 4). The horizontal and vertical planes do not show us the true shape of the elliptical surface of the top of the cone. To show this we make a view on an imaginary plane parallel with this surface and immediately over it, and in placing this view we follow precisely the rule that governs the arrangement of the others (Fig. 4, *a a*). Were we to adopt the other method we would be obliged to project the ellipse through the cone to a plane below it, as shown in Fig. 4, *a' a'*.

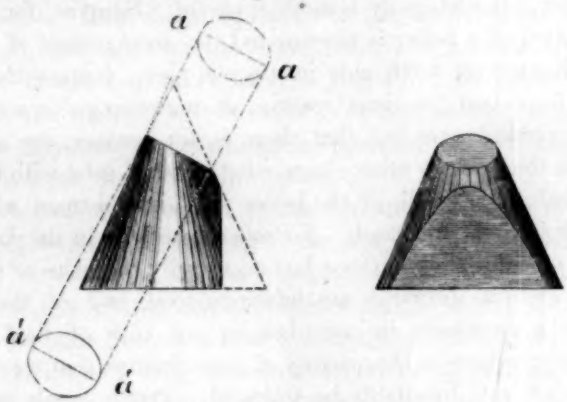

FIG. 4.

Let us take another illustration: a draughtsman at a large shop in this city was called on to draw a turning lathe, and, following the teachings of his school days, he arranged the various views as I have shown in a rough sketch on the blackboard, that is, he drew a front elevation, below that he drew a plan, and adjacent to the live head he put a view of the poppet head; while at the other end of the drawing was a projection of the live head. Now what was the result? The long legs supporting the lathe-bed—of little importance as far as dimensions are concerned—occupied the centre of the board, separated the plan and elevation of the bed, and, as in the case of the heads, the different views of the parts were as remote from one another as possible. The arrangement of the various views in a drawing is not simply a matter of preference or taste: it is a question of real practical importance. Perhaps if skilled draughtsmen alone had to do with drawings—or if draughtsmen would or could in all cases make their drawings as full and complete as possible—there would be no need to

discuss the matter, for, as I said, either system will show the true shape of any object if carried out logically and fully; but drawings pass into the hands of artisans who are rarely familiar with the rules of Descriptive Geometry, and for whom drawings should be arranged in the simplest and most easily comprehensible form. Then again, drawings cannot always be perfect, and it may be, indeed often is the case, that some detail is shown in but one projection; it then becomes a matter of grave importance that the stand-point from which the drawing was made should be clearly known. I think that it is in cross-sections that this ambiguity is most apparent. Suppose, for instance, that a section of a boiler is shown, and the arrangement of the tubes in this boiler are set forth only in this one view; suppose these tubes, for some important functional reason, are not arranged symmetrically about the vertical axis, but that there is, for instance, one more tube on one side than on the other—now whether that tube will be put in the right side or left side of the boiler will depend upon which system of projections was used. No one can be long in the draughting office of a machine shop without becoming sadly conscious of the readiness with which drawings are misunderstood, and of the curious fact that if a dimension in one place, or one view of half a dozen is wrong, somewhere in the process of manufacture that wrong figure or faulty view will inevitably be followed. People rarely pay much attention to these things until an expensive blunder is traced to some half-made drawing, and then the question is generally settled. In this way it has come to be, I think, without doubt, the almost universal custom in shops in England and America to arrange the views in what I have described as the practical or common sense method. This is, perhaps, strictly true only as regards the front and side views, for probably a majority of those who use the "common sense" arrangement here will inconsistently place the top view below the front. Some draughtsmen hold that the position of this view is merely a matter of convenience, and that its relative importance should determine its location; while others contend, with greater show of reason, that one inflexible rule should determine these positions, and that what is right in one case must be equally so in the other.

The Descriptive Geometry method is taught, I presume without exception, in the most noted European schools, and I understand is practiced generally in foreign machine shops; but even there neither plan appears universally adopted, and we find in text-books and else-

where drawings made each way. I have here tracings made by a distinguished professor in a foreign technological school which conform perfectly with our shop practice, and in Prof. Reulleaux's "Der Constructeur" many of the illustrations also accord with our ideas. I have here, too, some plates exhibited at the Centennial Exhibition by the French Department of Public Works. They are drawings made for use in the imperial schools. We find among them some in which the side elevations are placed exactly in accordance with American shop practice: the plans are invariably and inconsistently below the elevations. Indeed, among those who profess to be our authorities in England and America the same indecision exists. Here are a number of illustrations taken from an English work published about 1852 or 3, and we find both kinds of drawings among them. In our text-books the same state of things is apparent, and probably most of our schools teach the European method.

Our two leading schools of mechanical engineering, Cornell University and Stevens Institute, teach the Anglo-American, or, as I prefer to call it, the shop plan, and insist upon it strongly, while in the drawing schools of the Spring Garden Institute and the Franklin Institute the same ground is taken. Now, one difficulty which results from this division of opinion is this, that we rarely take up a work on mechanical drawing—Church's for instance—without finding drawings made both ways, and therefore whenever a mechanical drawing is presented, we must first analyze the different views until we find from just what stand-point each was made; and this is repeated by every man who examines the drawing. If, then, in a machine shop there are drawings made both ways, every workman, pattern-maker, foreman, fitter has to go through this process with a manifest loss of time and risk of error.

A few days ago I met a recent graduate of one of our leading scientific schools, who is now employed as a draughtsman in a large manufacturing establishment, and this subject being uppermost in my mind, I inquired of him what plan was followed by his employers. He described the usual shop plan, and said that it was rigidly enforced. I then asked him if he had been familiar with that plan before he began work in his present position, and whether he had been so instructed at college. He immediately replied:—"Why, ever since I've been at work I've been trying to unlearn the method I learned at college."

Now this furnishes a text upon which I should like to enlarge a little, especially as his experience corresponded precisely with my own, and with that of every college man of my acquaintance, who has gone into the shops. I, too, learned at college the Descriptive Geometry method of arranging the projections in a drawing, and as soon as I attempted to apply it in the shop I was taken to task for making indistinct drawings.

The value of education of a special character for those intending to become engineers is now widely recognized, and our colleges, almost without exception, are endeavoring to meet this demand by the establishment of departments devoted exclusively to teaching in the various branches of engineering. Large sums have in many cases been expended in the erection of proper buildings, the equipment of laboratories and workshops, and from these schools hundreds of young men are annually graduated, and go out to find employment, feeling that they have at least laid the foundations of a thorough training in the professions they intend to follow. If such a young man finds that the teachings of his Alma Mater differ from the practices of the workshop or engineering office, that the methods he has learned at the expense of so much pains and time are regarded on the one hand with contempt as obsolete, and on the other, perhaps, with derision as impracticable or "too scientific,"—for your old-time machinist is frightened at the mere mention of the word—if, I say, the college man finds he and his college differ from the shop, he concludes at once that the shop is wrong; but if after a fair trial in any particular case he is compelled to admit that the shop ideas are correct, he feels a little indignant that he has wasted time in learning that which he has now to unlearn, and his respect for his college and the wisdom of his teachers just that much decreased.

I do not wish to disparage the value of Descriptive Geometry, or the indubitable importance to the engineer of a thorough scientific education.

Descriptive Geometry is only the expression of the principles of mechanical drawing in scientific form; no draughtsman can work without applying these principles at every step, although he may not be aware that they have ever been scientifically formulated.

But while urging the value of science and education, I wish to emphasize the opinion that the instruction of the schools should conform to the best shop practice, especially when, as in the case of pro-

jections, the superior advantages of what Prof. McCord—perhaps the best American authority on mechanical drawings—describes as the "common sense system of making drawings," can be so easily demonstrated. Those who have a pecuniary interest involved in a branch of manufacture can generally be relied on, in the long run, to adopt that which is best fitted for their use; but if our instructors are not prepared to endorse what the makers and users of drawings tell them is practically best, is it asking too much of them that they should at least describe to their students the various plans in use? If they, on the other hand, allege that they do not know the practice of the shops, may we not justly say that it is their business to inform themselves?

In the present case the "common-sense" system can be so easily demonstrated to be the better, that it appears somewhat strange that it is not taught by *all* of our schools and colleges. In this connection I may cite, as typical cases, the experience of two prominent Philadelphia concerns. At the Baldwin Locomotive Works so much trouble was caused by misunderstanding drawings, and so many mistakes occurred, that a positive rule was at last put in force that all drawings should be made with the views nearest the stand-point from which the view was supposed to be seen; and, for their guidance in cases of doubt, the workmen were instructed to bend the drawing backwards between the two views, the doubtful one and the one nearest it, when its true relation would at once appear.

Again, Wilson Bros. & Co., the prominent firm of engineers and architects, have found it a decided advantage to make such of their drawings as are intended for the shops in accordance with the usual American shop plan.

We are taught in most of our text-books to draw any object we desire to represent by referring it to a "ground-line," which is the intersection of the vertical and horizontal planes; and we learn that the distances of the views above or below the ground-line mark the distances of the object drawn from the planes of projection, and other facts of equal value; for instance, we are told to project our dimensions from one view to another by a system of parallel lines and arcs, but, so far as I am aware, mechanical draughtsmen never draw in this way. The intersection of the planes of projection is never regarded for a moment, and I fear that many of our best mechanical draughtsmen are entirely unfamiliar with even the terminology of Descriptive Geometry, which, however valuable it may be as a mental exercise, is

by no means a necessary preliminary to a pretty thorough knowledge of mechanical drawing; and, in fact, it seems to me to hamper with unnecessary difficulties a very simple subject.

This is especially the case in such a school as that of the Franklin Institute, which is designed to meet the wants of those who are actually engaged by day in the practice of some mechanical pursuit, and many of whom have had very limited school education. With such scholars it seems clear that the general principles and practice of mechanical drawing can be taught more directly and clearly than by following in detail the course of reasoning laid down in the geometries. These start out with the consideration of the position of a mathematical point as situated in space, and proceed from thence to the location of lines, planes, and finally solids, forming thus a logical sequence which, however, demands on the part of the learner an amount of mathematical training or familiarity with mathematical modes of thought, which we must not look for among the pupils of the Franklin Institute or the apprentices in a mechanical drawing office.

The usual method of procedure in making a mechanical drawing differs in many respects from that generally recommended in the books, and is probably based on the requirements of practice. Thus, drawings are usually made with reference to centre lines. In beginning a drawing a horizontal line is generally first drawn, and then a perpendicular to it; the first may be one edge of the object, its ground line, or an axis through some important part, according to the nature of the thing drawn. Suppose we were about to draw the lathe I have shown in my sketch on the blackboard. We should probably first draw the floor line, then at a known distance a line passing through the spindles, and this would be our most important centre line or axis. On these lines and on perpendiculars to them we should measure off the coördinates of the different determining points, that is, their distance from these axes, and join them by the necessary lines. We may measure these distances with the scale or step them off with the dividers, just as we please, but we object to confusing our drawing with a lot of broken projection lines, and we should arrange the views just as the shape of the object and the size of our paper require, and never think for a moment of planes or ground line. We should put in just as many views as may be required to show the object with perfect clearness, if it takes twenty; but if one is enough to show our meaning without doubt, then let us make no more, but whether we have

two or twenty views, let us follow in their arrangement one system only. Let the mechanic understand clearly that he will always find these views in the same relative positions.

The great number and variety of parts in many mechanical devices often render mechanical drawings extremely complex, and great care and judgment must be exercised to show all that is necessary without confusing the drawing with a multiplicity of lines. To increase the clearness of drawings, one "convention" in common use is what is known as "line-shading," which originally consisted in strengthening all lines representing surfaces not illuminated by the direct rays of the sun. The light was supposed to come from over the left shoulder of the draughtsman at an angle of 45° elevation from the horizontal plane, and an equal inclination to the vertical plane; then objects were shaded as shown in Fig. 2. But gradually this has been changed, and we now assume that shade-lines on the right and lower sides of an object denote a raised surface; on the upper and left hand they mean a depression. An appearance of solidity is thus obtained, and a single glance serves to tell us whether a part is raised above or sunk below the general surface, while we have no need to ask ourselves if the view we examine is plan or elevation.

The other great advantage of "line-shading" is that it gives character to a drawing and relieves the sameness produced by lines of even thickness. Many draughtsmen accomplish this by brush-shading parts of a drawing. It is generally impracticable in mechanical drawing to thoroughly shade all parts, but by tinting parts, for example, the forgings blue, and shading them a little, they are at once brought out of the drawing, eliminated as it were, and it becomes proportionately easier to follow the rest.

It seems scarcely necessary to allude to the subject of figuring drawings. It is now happily admitted on all sides that a working drawing should have all the necessary dimensions marked in figures, and that no workman should be allowed to measure a drawing. The privilege may be allowed the pattern-maker in minor details where surfaces are not to be finished, but distances between centres and all dimensions for finished surfaces should be set down on the drawing, and followed absolutely. I am aware that these views are not entirely general, for I observe that a recent writer on the subject pleads for wooden models of all the parts of a drawing, "because," says he, "it is so difficult to set your calipers to the lines on a draw-

ing." I have no doubt *he* is the kind of a man who will talk about a size as being "little full scant"—an individual about as mechanically worthy of respect as the man who, when he wanted a door to fit a door-way in his house, converted his arms into a pair of calipers, and walked off to the carpenter's with his hands in the air, his elbows glued to his sides, and the size of the door between his outstretched hands.

As outside views will not usually show everything about the object drawn, we have recourse to cutting it by one or more imaginary planes, and thus presenting cross-sections of the various parts. In the disposition of these cross-sections the principles that determine the position of the elevations must be observed. If we put an elevation of the right hand end of the object adjacent to that end, and draw it as though we stood at that end and looked towards the left, then cross-sections parallel to that view should also be placed at that end and be drawn as though our point of view was the same, and as if the intermediate portion of the object, that is, all parts between us and the section plane were removed.

To distinguish projections of this kind from outside views, we have recourse to one of two conventional modes. We either tint them a color which we decide is to represent the material to be used, or we "cross-hatch" or "section-line" them, that is, mark the surface of the imaginary section with a series of parallel lines inclined at an angle of 45° with the horizontal and vertical lines; these lines we make of various colors indicative of the material represented. Thus black lines indicate cast iron; red, brass, and blue, wrought iron or steel, while if the drawing be tinted a light tint of India ink or of neutral tint, it is usually taken to signify cast iron; yellow, brass; blue, wrought iron, and purple, steel.

Of course, architects and other makers of constructive drawings adopt other colors to represent the different materials with which their drawings deal. Section-lining has the important advantage over tinting that it serves to separate to the eye the various pieces of which the machine in section is composed; for by simply inclining the lines in adjacent pieces in opposite directions the various parts are at once distinguishable. Of course care must be taken not to change the direction of the cross-hatching in the same piece.

I have said that we denote the different materials by differently-colored section-lines or brush-tinting; but the now general use of

blue prints necessitates a modification of this plan. In the first place color does not show in the print in any way except as a shade of blue or bluish white, varying only with the opacity of the colors. Hence we must for sections use cross-hatching, and as colors will not serve to distinguish different materials, we have recourse to a different arrangement of lines, thus: equally spaced lines may denote cast iron, lines grouped in twos, brass, and if arranged in threes, wrought iron. In these conventions each shop is a law unto itself only, and no unanimity exists among them.

In urging the necessity that exists for extending the knowledge of mechanical drawing, as useful, in fact imperatively necessary, not only to the draughtman, architect, engineer or designer, but to every artisan, mechanical pattern-maker, blacksmith or carpenter, or other handicraftsman, who is or may be called on to work to drawings. In urging, I say, the vast importance to us of this branch of education, I do not wish to disparage for a moment the value of free-hand drawing. In fact, I would not restrict the term mechanical drawing to that done with instruments and to an exact scale. A free-hand sketch may be a mechanical drawing if it be a constructive drawing, that is, if it so represent on a flat plane the size or shape, proportions of something to be constructed, that it will serve to impart the proper idea to the man who is to make it.

I have often observed a tendency among persons absolutely ignorant of drawing to put their graphic explanations in the form of rude attempts at perspective drawing; that is, they try to draw things as they see them, but also try to show details of construction which they cannot see, and the result is generally a monstrosity which tells less of the true form than a less ambitious and more easily made sketch would if the maker knew anything of mechanical drawing. A knowledge of free-hand drawing is of the greatest value to all who have to do with mechanical drawings. In fact, facility in off-hand sketching is of perhaps more practical value than great dexterity in the use of instruments at least to all but the professional draughtsman. Men who make the neatest and most accurate drawings often cannot make a presentable free-hand sketch, while those who do both well, find their skill has a proportionate market value.

A recent writer says: "The object to be made must first be clearly conceived in the mind, then portrayed correctly in a drawing, from which the artisan learns how to make it." Now this is not, I think,

strictly correct. It is seldom that a clear mental conception of a complex device can be formed at once. The idea at its inception must be crude and vague, and to attempt to arrange its details mentally is analagous to the effort involved in the solution of an algebraic or geometrical problem without the aid of pen or pencil. The designer must think, pencil in hand, and under his facile fingers sketches grow, are changed, erased and recommenced, as the obstacles to be overcome, and the faults in the design are developed by the graphic representation which accompanies the mental process and serves to record each step.

As I have already had occasion to remark, a knowledge of the principles of drawing is of primary importance to the artisan, the mechanic, as well as to the draughtsman or designer. Unfortunately our public school system does not recognize this fact, and proper instruction in drawing is not given, as it should be, with lessons in reading and writing; and even in those schools which attempt to teach it, we rarely find it adequately or thoroughly done.

Now, it is in a measure to supply the lack of this kind of instruction that the Franklin Institute Drawing School was established, and we can have no better argument in proof of the fact that it supplies a real and recognized *want* than is found in its remarkable growth; its classes are constantly increasing, and from 75 students two years ago the attendance has grown to over 160 at the present time. Of this large number over 120 are actually engaged in the practice of some mechanical pursuit, that is, they are machinists, pattern-makers, draughtsmen, etc. How are we to account for this large attendance except by assuming that the value of drawing is becoming recognized, and that students know that here drawing is taught by practical draughtsmen and according to methods in actual use? In regard to the questions upon which the doctors disagree the Institute School takes no middle course, but teaches boldly and clearly those methods and conventions which practice has demonstrated to be the best. And it seems to me that the Institute might with advantage go still further and attempt to assimilate the differences in practice to one common standard, formed of the best parts of all systems. In this way, perhaps, a Franklin Institute Standard of Mechanical Drawing might be established, which would tend—as in the case of screw threads—to uniformity in shop practice.

The drawings of any establishment, however, must always have an

individual character, which is determined principally by the shop standards and facilities, the gauges, the reamers, taps, mandrils, and other special tools and appliances with which that particular shop may be equipped. The draughtsman must be guided by a knowledge of what the shop has and what it can do, and must arrange his drawings with these facts constantly before him. Drawings fitted for one shop might, therefore, be far from right for another shop, but this is no reason why a drawing made in one shop should not be perfectly understood in any other.

I feel, ladies and gentlemen, that this has been merely a cursory and superficial review of the subject, and I am afraid you have found it a dry one. But if I have succeeded in impressing any of you with the really vast importance of drawing as a branch of education, more or less useful to all men, and also with the necessity that it should be taught in the schools as it is used in the shops; if, I say, I have made this clear to you, I shall not, I am sure, have bored you in vain.

Needle Making.—At Borcette, which is the most important centre of needle manufacture in Europe, the conversion of the steel wire into rough needles requires 20 operations; the principal of which are the measurement of the wire, the scouring, the winding off, and the cutting into lengths equal to two needles. The pointing is done with two grindstones. By the aid of a copper finger-stall the workman holds 50 wires at a time, which are heated to redness by the friction. The dust and powdered steel formerly produced consumption in the workmen after a few years, but by the aid of ventilators this evil has been entirely overcome. After the sharpening, boys cut the wire in two, flatten the head, anneal and punch the eyes. The tempering and annealing require nine operations, but they are done in piles of 15 kilogrammes (33·69 lbs.), containing more than 300,000 needles. One million needles are polished at one time. There are five operations, which are each repeated seven or eight times. The needles are put in hollow rollers with small hard stones and colza oil. The stones are gradually pulverized, and the friction of the powder gives the principal polish. For the final polish oil and coarse bran are used. The sorting of the polished needles requires five operations, and after the burnishing they are put into papers.—*Revue Industr.* C.

THE APPLICATION OF FRICTIONAL ELECTRICITY TO THE PURIFICATION OF MIDDLINGS.

By Robert Grimshaw.

Abstract of a paper read before the Franklin Institute, October 19, 1881.

For the benefit of those not present at my lectures before the Franklin Institute last winter, upon Modern Milling, I crave the indulgence of those who then honored me with their attendance, in order that I may give a brief and general outline of what constituted old-fashioned milling, and what are the changed principles which go to make up modern milling.

Wheat, from which is made most of the flour we use, is a berry formed of two lobes, between which there is a lengthwise crease. This berry consists for the most part of white starch granules, surrounded by white layers of cells containing a large proportion of gluten, which is nitrogenous, and the entire mass enveloped in thin brittle coats of brown woody fibre, called bran.

There is also a small, waxy, yellow germ, very nourishing, but discoloring to the flour.

Wheat is bought by weight more often than by measure; and the farmer is not careful to remove from the berries the oats, grains of cockle and other seeds, chaff, chess, sticks, straws, gravel, sand, etc., which are mixed with the berries; nor to remove from the face of each grain the very fine dirt adhering thereto. Still less is he careful to rub off the beard or fuzz found at the end of each grain, and to brush out the bluish crease dirt packed away between the lobes. These little trifles the tiller of the soil leaves to the one most interested—the miller.

While the object of milling (outside of that done by those who advocate the bran as food) is to get all the starch and glutenous cells in the shape of fine, sharp flour, free from all bran particles, grease, dirt and other foreign matter, and to get the bran in as large scales as possible, free from adhering or intermixed starchy and glutenous granules,—the old-fashioned miller (and by him I mean nearly every miller up to fifteen years ago, and many of the present day, of the type who believe that a water wheel runs faster at night than during the day,) goes at this task in this way:

First, by screens and wind currents he takes out all loose impurities, heavy and light, except bits of iron and steel wire, which last are removed by magnets in the spouts. Then, by rubbing the berries among themselves between revolving drums and a perforated sheet metal case, all the while subjected to a current of air, which rubs off and blows away the fuzz and most of the surface dirt. With a brush machine he gets out most of the bluish crease dirt. If the weather be cold (or even in warm weather certain grades of wheat with bran that is very brittle) he toughens the bran by means of a steam heater. While the grain is yet warm he passes it between two revolving horizontal mill stones; the faces of these mill stones being made perfectly plane, kept in parallelism, and dressed to a nicety, with furrows and smooth faces determined by the character of the stone and wheat and by the whim of the miller. The result of the friction and pressure between the smooth plane surfaces, and of the cutting by the edges of the pores and of the furrows, is to grind the berries into a mass called "chop" or "Graham," composed of bits of broken berries called "middlings," flour in starchy powder, germs, and bran scales having middlings and flour sticking to them.

In old-fashioned milling the chop was separated by sifting in inclined revolving cylinders having walls of fine silk of fineness varying from head to foot, into middlings (or bits of wheat), bran, and flour proper. But the middlings had flour and very fine bran mixed with them; the bran had some middlings and flour adhering to it, and the flour contained very fine bran particles. The bran was either passed between mill stones to rub off some of the middlings and flour, or sold for feed without cleaning. The flour was divided, by bolting, into grades of varying fineness, color, and "strength" or doughing capacity. Those portions of the flour which contained most gluten cells were the "strongest," in two senses: *First*, they would make more dough and more bread, per 100 pounds, than those portions having less gluten; for gluten absorbs more water than starch does. *Second*, they would make more muscle and be more strengthening and more nourishing than the starchy flour. But the middlings, although containing more of the gluten cells than any other portion, and hence entitled to the most distinguished consideration, were, metaphorically speaking, thorns in the side of Mr. Dustycoat. How were these particles of bran, so fine as hardly to be distinguished by the naked eye, to be taken out from the middlings? It must be borne in mind that

these bran particles, which would not only lower the percentage of the nourishing parts of the flour, but (more important to miller and merchant) injure its beautiful white color, are just as fine as the flour; hence sieving would be of no use. So the middlings were either sold as feed at so much a ton, or run back into the eye of the mill stone to be ground up with the wheat, the miller trusting to luck to get more good white stuff into the flour than he put worthless dark stuff in.

Such being the conditions, the enterprising miller endeavored to make as few middlings as possible; and with this object dressed the surface of his stone so that there would be about one-third in furrows and two-thirds in the "lands" between. This left plenty of rubbing surface, and ground, rather than granulated, the berry. The furrows were made deep, say one-fourth to one-half inch for a four foot stone.

But as things are now, under the more enlightened practice of modern milling, the despised middlings, the skeleton in the closet of the miller, have become his chief desideratum. And why? Because some one (to whom the milling world should erect a statue in like manner to that in Boston to the unnamed discoverer of anæsthetics) found that it was possible to get out of these middlings even the finest discoloring matter; and although such methods have been employed gradually for many years, it is not until the last ten or fifteen years that machines by which middlings were purified have been in the market, doing satisfactory work, and selling at reasonable prices.

There are two types in general use where modern milling is employed: the sieve and air current machines, and the centrifugal. In the first, the unpurified middlings are passed down an inclined sieve cloth with bolting silk of increasing coarseness, and having an endless shake. Through the downward traveling mass of middlings and bran a carefully graduated current of air passes. The impurities are blown up and away, the fine purified middlings pass through the screen, and the coarse stuff tails over at the end. In the centrifugal machine, advantage is taken of the different specific gravities of the particles of bran and those of middlings, and the mixed mass is thrown out from a revolving central discharge, across ring-shaped currents of air; the different grades of material falling down ring-shaped spouts at different distances from the centre and being carried to where they are desired.

The purified middlings, no longer despised, no longer sent back to the wheat stone to be run in common with the whole berries, are

treated with royal honors, and given to special devices for making from them the well-known "patent" flour. The stone for middlings grinding should best be of hard texture and close grain, because there is no need of the cutting edges of large pores; and smaller mill stones may be employed than for wheat grinding.

The aim being to get as many middlings, and to have these as large and sharp, as possible, attention has been paid to the construction of devices for granulating the wheat with a view to the production of middlings as a specialty. One device was to employ a series of several mill stones, the first pair set so far apart, and dressed so coarsely, as merely to crack the wheat, the next pair being set closer, etc., the berry being gradually reduced into middlings, bran, and a little flour of rather poor grade. Between each two breaks, or reductions, these three elements were separated by rotating reels suitably clothed with wire-gauze, or with silk. This system of granulation constitutes gradual reduction by mill stones. It is not, of course, adapted to small mills; for the necessity of having three to five sets of breaking burrs prevents its adoption in mills having less than ten sets of burrs.

A more advanced practice is cylinder- or roller-milling. In this system, instead of employing for granulation large, flat, circular surfaces, of which those portions near the circumference pass each other at a higher speed than those near the centre or eye, there are used cylinders revolving either together or against a breast or concave; and by these the grinding is effected, not by contacting surfaces with varying speeds, but by a simple line of contact, of which all parts have the same grinding speed.

For breaking the wheat into middlings, and for bran cleaning, these rollers are generally of chilled iron, running in pairs, with from eight twisting grooves per inch of circumference for the coarsest breaks, to thirty for the finest.

For flouring the middlings, unglazed porcelain rolls are used. For flattening the germ, and bringing the middlings to regular sizes, plain chilled iron rolls are employed. There are also used single rolls of stone working against stone or against iron breasts, and single iron rolls working against adjustable iron concaves.

These cylinder granulators make more, better, and sharper middlings than the burrs, heat the chop less, and do not break and cut up the bran so much as the burrs. Besides this, they take up less room and consume less power, and are by all means the best for mills making

over one hundred barrels of flour per twenty-four hours, especially from hard spring wheat, which has very brittle bran and is rather difficult to handle with burrs.

Saying but little of the bolting process, for which we have but little time, we come at once to the purifier, which as a class is *facile princeps* the king of milling apparatus.

I shall first show upon the screen one of the best as well as one of the most recent wind purifiers (the Case), in which, as you will see by the general view and the lengthwise vertical section thrown upon the screen by Mr. Holman, there are two separate screens, one above the other, each with its separately adjustable wind supply. The unpurified middlings having been fed to the upper end of the first screen, by a specially contrived feed box, designed to distribute the middlings at a uniformly regular rate, and evenly upon all portions of the width of the screen, pass along over the fine cloth, receiving a lengthwise jarring action as they pass from the fine to coarser cloth, and being held up in suspension by the currents of air from below, which carry away the light and worthless particles and let the sharp, fine middlings go through the meshes of the silk, while the coarse matter and germs tail over at the end.

I now come to the electric purifier, which instead of employing air currents to lift up and hold in suspension the particles of bran fibre and other impurities, calls into operation the attractive power of frictional electricity. One of the most familiar lecture experiments of our school-boy days is the rubbing of a stick of hard wood, rubber, glass or shellac with a woolen rubber and causing it to pick up small light particles of paper, hair, etc. The friction caused the generation of frictional electricity, which was called vitreous or resinous, according as the excited substance was glass or resin.

The machine consists of a sieve to effect separation by size, and hard rubber rolls, revolving against sheepskin rubbers to excite electricity, to effect separation by weight; the whole mounted in a suitable frame.

The sieve is on the top of the frame, and below it are the necessary conveyors to remove the purified middlings which pass through the sieve, and slides to separate them as desired by the miller.

The hard rubber rolls are each nine inches long and six inches in diameter, three being placed upon one shaft, and the shafts being fourteen inches between centres.

The rate of revolution is about thirty turns per minute, which causes

the bran and the lighter impurities to rise above the heavier portions, and within the attractive influence of the rolls. At the head the sieve is clothed with, say four or five feet in length, of a No. 8 cloth (having 7059 meshes to the inch), through which the very fine middlings pass with the flour dust. For the first operation the numbers of the cloth of the screen increase in coarseness from No. 6, having 5184 meshes to the square inch, to No. 0, having 1444 meshes per square inch. For subsequent operations the clothing should be finer, running down to as fine as No. 2 (2704 meshes) at the tail for the last operation. The work of the electric part of the apparatus commences about two feet from the head of the machine. The bran and the impurities being lifted up and taken out by the electric action, the pure middlings are shaken through the sieve according to their size, and may be run together, or separated according to size, at the will of the miller.

It is better that before purification the middlings be graded according to size, because if the machine be clothed and adjusted for one size it will not work as well upon another, or upon several sizes mixed. It will pay to grade in all cases where "middlings milling" is practiced, and the capacity of the mill is over one hundred barrels per twenty-four hours.

The frame of the purifier is ten feet long, four feet high, and three feet wide, the sieve having a cloth surface composed of three strips each nine inches wide and nine and one-half feet long, over which there are eight rolls. The bolting surface of twenty-one square feet is rated at a capacity of 500 to 600 pounds of middlings per hour. It will be noted that in the ordinary wind purifier, in which the particles of bran are lifted by the air current passing through the sieve cloth, and impelled either by a blast fan or an exhaust fan, or both, there is trouble from the particles clogging the under side of the cloth, rendering it necessary to free the machine by some special device, generally a traveling brush, although knockers, whips, rubber balls, etc., are used. The electric purifier requires none.

The power required is stated by the makers at about one horse-power per 1000 pounds of middlings per hour, that is, about one-half horse-power for each machine.

One of the most objectionable features of wind purifiers is the necessity of having some receiver for the fine dust blown from them—there being generally a dust-room or stive-house, which is especially

liable to fires and explosions. The electric purifier making no dust, requires no dust-house or dust-collectors.

To get down to the details of the system, we will first consider what is required for a small mill of 75 to 80 barrels capacity per twenty-four hours. We will assume, in the first place, that by neither the wind nor the electric system can middlings be thoroughly purified with less than three operations: that is, without some portion of every lot of middlings passing three times over a sieve. Where the capacity of a mill is as large as 225 to 250 barrels of flour per twenty-four hours three machines are needed. Where the capacity is as small as 75 to 80 barrels per twenty-four hours there is used what is called a "combination" machine, which is practically three purifiers in one.

The "combination" machine has rubber cylinders and sieve the same as described above. It differs, however, in that the feed hopper is divided into three sections, corresponding with the three sieve sections. The first section of the sieve, for coarse roller mills middlings, is clothed with 8, 3, 1, 0 and 00 silk; the second with 8, 6, 3, 2, 1 and 0, and the third with 8, 3, 2 and 1. The ungraded middlings are spouted directly to the first section of the feed hopper and thence on to the first sieve section. There are underneath the first and second sieve sections two conveyors each, the upper conveyor spouting directly to the flour-stones or rolls, and the lower to an elevator which discharges into the next section of the feed hopper. Under the third sieve section is one conveyor, spouting, with the upper conveyors of the first and second sections, directly to the flour stones or rolls. Sweeps are arranged to run through the offal troughs to keep the first section offal separate from the second and third sections. A spout is arranged to take the tailings of the sieve from all sections to the smooth rolls.

So, when we come to the use of this machine, the middlings passing over the first sieve section which fall through the 8 cloth are finished, and go directly to the flour rolls spout by the upper conveyor, while those falling through the rest of the sieve are carried by the lower conveyor to an elevator, which discharges them into the second section feed hopper, *en route* for the second sieve section. All the middlings in this section passing through Nos. 8, 6 and 3 cloth are finished and are conveyed by the upper conveyor to the spout that leads to the flour stones or rolls, while those passing through the remaining portion of the sieve are conveyed by the lower conveyor to the elevator and by it discharged into the third section of the feed hopper, which in turn are

fed on to the third section of the sieve. The middlings passing through the whole length of the sieve of the third section are purified and conveyed to the spout that leads to the flour stones or rolls.

The tailings from all sections are spouted to smooth rolls for flattening and further reduction, and go back with the regular chop into the first section of the feed hopper.

The offal from the first section, which is very poor and only fit for feed, is conveyed from one side of the machine into some receptacle, while that from the second and third sections, which is rich enough for reduction to a low grade of flour, is conveyed into another from the other side.

When the capacity of a mill is sufficient for three machines, "simple" machines are used in place of "combination," the different machines taking the place of the different sections in the "combination," and operating in substantially the same way.

[Since reading the above paper the writer understands from the manufacturers of the machine that they have discovered the efficiency of the machine as at first constructed, and as above described, can be greatly improved by the use of—in place of hard rubber in cylindrical shape for the attractive force—flat plates to move backward and forward. This change will allow a greatly increased electrified surface presented to the middlings over the same sieve surface—an increase of three or four times, which must necessarily increase the capacity of the machine and the thoroughness of its work, and very considerably decrease the cost of construction.

The cylinder apparatus has been in operation in the Atlantic Mills at Brooklyn for over a year, and the proprietors, F. E. Smith & Co., say that it saves them ten to twenty cents on every barrel of flour.]

Porous Bricks.—The association of proprietors of steam engines in the north of France have made numerous experiments which show that many of the bricks that are employed in building furnaces are so porous as to allow an easy passage for the air. In consequence of these experiments they advise that no bricks should be employed for the purpose which are not very compact and refractory, and that they should be either glazed upon the outside or covered with an impenetrable varnish.—*Chron. Industr.* C.

ON THE CONSTANTS IN GORDON'S FORMULA FOR THE STRENGTH OF COLUMNS.

By MANSFIELD MERRIMAN,
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Gordon's formula for the discussion of the strength of columns is, in its most general form,

$$\frac{P}{A} = \frac{m}{1 + n\frac{l^2}{r^2}}$$

in which P denotes the breaking load, A the area of the cross section of the column, l its length, r the least radius of gyration of the cross section, and m and n are constants, whose values depend on the kind of material and arrangement of ends of the column.

In order to ascertain the signification of the constants m and n let us give a mathematical deduction of the form of the above formula.

Let a column whose length is l and cross section A be loaded with a weight P. The average unit compressive strain on the cross section is then $\frac{P}{A}$. But in consequence of the bending, or sidewise deflection, of the column the unit strain on the concave side becomes greater than $\frac{P}{A}$, and that on the convex side less. Let S represent the greatest unit compressive strain on the concave side, and F that portion of S due to the flexure. Then

$$S = \frac{P}{A} + F$$

Now, provided that the material of the column is not strained beyond its elastic limit, the value of F may be deduced from the usual equation for the flexure of beams, namely,

$$M = \frac{F\,I}{c} \quad \text{or} \quad F = \frac{M\,c}{I},$$

where I is the least moment of inertia of the cross section, c the distance from the concave side to the neutral axis of the flexural strains, and M the bending moment of the external forces with reference to the neutral axis. We have then

$$S = \frac{P}{A} + \frac{M c}{I}$$

But in the case of the column $M = P \Delta$, where Δ is the maximum sidewise deflection, and $I = A r^2$. Hence

$$S = \frac{P}{A}\left(1 + \frac{\Delta c}{r^2}\right)$$

which may be written

$$\frac{P}{A} = \frac{S}{1 + \frac{\Delta c}{r^2}}$$

In order to determine Δ we must turn again to the theory of the elastic flexure of beams, where we find for a beam supported at both ends and loaded in the middle

$$\Delta = \frac{F l^2}{12 E c}$$

where E is the modulus of elasticity of the material. From this we have

$$\Delta c = \frac{F l^2}{12 E} = \left(S - \frac{P}{A}\right)\frac{l^2}{12 E}$$

and by substitution in the above value $\frac{P}{A}$ we find

$$\frac{P}{A} = \frac{S}{1 + \left(S - \frac{P}{A}\right)\frac{l^2}{12 E r^2}} \qquad (a)$$

which applies to a column with ends arranged similar to those of a beam supported, namely, to a column with round or hinged ends.

In the same way we find for a column with fixed ends a similar expression, having 24 in the place of 12; and for a column with one end round and the other end fixed also a similar expression, having 17 in the place of 12.

It thus appears that the constant m in the formula

$$\frac{P}{A} = \frac{m}{1 + n\frac{l^2}{r^2}}$$

signifies the greatest unit compressive strain S due to the stress P, provided the elastic limit be not exceeded. And also, under the same restriction, that the constant n has the following values:

$$n = \frac{S - \frac{P}{A}}{12\,E} \text{ for round ended columns,}$$

$$n = \frac{S - \frac{P}{A}}{17\,E} \text{ for one end round and the other fixed,}$$

$$n = \frac{S - \frac{P}{A}}{24\,E} \text{ for flat or fixed ended columns.}$$

It hence is evident that n is not a constant, as it varies with $\frac{P}{A}$, and for columns strained to the same point S its value is greater the greater the length of the column, since we know from experiment that $\frac{P}{A}$ decreases when the length of the column increases.

There are no means of determining what the values of m and n might be when the material is strained beyond the elastic limit, for the laws governing the resistance of materials in that condition are as yet only imperfectly understood. Usually Gordon's formula is applied to the rupture of columns, and m taken to be the ultimate unit compressive strength of the material; yet it is well known that for wrought iron, for instance, the usual value, $m = 36{,}000$ pounds per square inch, is much less than the ultimate strength. And it is also known that the formula entirely fails to represent the results of experiments unless columns shorter in length than about fifteen diameters are excluded, although its deduction contains no such restriction in regard to length. It hence appears that Gordon's formula should be regarded as of an empirical nature, and not be considered as representing at all the actual laws connected with the rupture of columns.

Formula (a) deduced above appears in an unsatisfactory condition owing to the presence of $\frac{P}{A}$ in both members of the equation. Solving it for $\frac{P}{A}$ we observe, with surprise, that

$$\frac{P}{A} = 12\,E\,\frac{r^2}{l^2}$$

which is identical, except in the constant (which should be π^2), with Euler's formula for the elastic resistance of round ended columns.

CHRONOLOGICAL TABLE OF AMERICAN PATENTS.*

By E. HILTEBRAND,
Librarian of the Franklin Institute.

In the Patent Office reports published prior to 1843 the names of patentees only appear with the subjects and dates of patents granted. In 1843 the publication of claims began with Wilbar's Patent, numbered 2901. There were granted, therefore, 2900 patents of which the claims or other descriptive matter have never been printed for public use by the Patent Office.

In the year 1826, when the *Franklin Journal* (now THE JOURNAL OF THE FRANKLIN INSTITUTE) was established, there was printed therein a list of the patents granted between December 12, 1825, and December 31, 1827, but without the claims. In the year 1828, however, it was decided to publish the claims, with remarks by the editor, or other descriptive matter of the patents. This was continued until March, 1836, from which time, until October of the same year, the claims were omitted and the names of patentees and subjects only, printed, as was done prior to 1827.

In 1837 another change was made, and the printing of the claims was resumed, and continued until the end of the year 1859. (From 1860 to date the claims and specifications are numerically arranged in the official reports, and are accompanied by alphabetical indexes of patentees and subjects.)

These lists, which sometimes presented the patents of one month, or those of a shorter or longer period, were published in an irregular manner, as will be seen by comparing the column showing the date of the granting of a patent with that showing the date of publication of the volumes of the JOURNAL. The following table is therefore intended to aid (provided the date of the granting of a patent is known),†

1st. In finding at once those claims of patents granted prior to 1843 which were published in this journal.

2d. In finding the claims of any patent granted between 1843 and 1859, inclusive, much more readily than from the Patent Office publications bearing those dates.

*June, 1828, October, 1833, and November and December, 1836, were not published.

† Should the title of a patent, or name of patentee, be known, and *not* the date of the granting of the patent, it is necessary to refer to the "Subject Matter Index of Patents, 1790 to 1873," Washington, 1874, in which the date will be found; then refer to corresponding date in the table, where, on the same line, is given the number of the volume containing the description.

TABLE *of American Patents published in* THE JOURNAL OF THE FRANKLIN INSTITUTE *between the Years 1826 and 1860.*

Year and Months in which Patents were Granted.	Series.	Volume.	Whole No. of Vol.	Date of Pub. of. Vol.
1825 December 12 to December 31	1	1	1	1826
1826 January 1 to April 26	1	1	1	1826
1826 April 12 to August 30	1	2	2	1826
1826 August 31 to September 14	1	3	3	1827
1826 September to October	1	4	4	1827
1826 November 4 to 16	1	3	3	1827
1826 November 20 to December 30	1	4	4	1827
1827 January 3 to February 15	1	4	4	1827
1827 February 15 to April 10	1	4	4	1827
1827 February 15 to December 31	2	1	5	1828
1828 January and February	2	1	5	1828
1828 March to May	2	2	6	1828
1828 July to October	2	2	6	1828
1828 October to December	2	3	7	1829
1829 January to March	2	3	7	1829
1829 April to September	2	4	8	1829
1829 October to December	2	5	9	1830
1830 January to March	2	5	9	1830
1830 April to October	2	6	10	1830
1830 October to December	2	7	11	1831
1831 January and February	2	7	11	1831
1831 March to June	2	8	12	1831
1831 July to December	2	9	13	1832
1832 January to May	2	10	14	1832
1832 June to December	2	11	15	1833
1832 Supplemental list to July	2	15	19	1835
1833 January to June	2	12	16	1833
1833 July to September	2	13	17	1834
1833 Supplemental list to August	2	15	19	1835
1833 November and December	2	13	17	1834
1833 December	2	14	18	1834
1834 January to May	2	14	18	1834
1834 June to November	2	15	19	1835
1834 December	2	16	20	1835
1835 January to May	2	16	20	1835
1835 June to November	2	17	21	1836
1835 December	2	18	22	1836
1836 January to March	2	18	22	1836
1836 April to October	2	18	22	1836
1837 January to March	2	20	24	1837
1837 April to August	2	21	25	1838
1837 September to November	2	22	26	1838
1837 November	3	8	38	1844
1837 December	2	22	26	1838
1838 January and February	2	22	26	1838
1838 March to June	2	23	27	1839
1838 July to December	2	24	28	1839
1839 January to May	2	25	29	1840
1839 June to October	2	26	30	1840
1839 November and December	3	1	31	1841
1840 January to April	3	1	31	1841
1840 May to October	3	2	32	1841
1840 November and December	3	3	33	1842
1841 January to April	3	3	33	1842
1841 May to August	3	4	34	1842
1841 September	3	8	38	1844
1841 October and November	3	9	39	1845

Year	and Months in which Patents were Granted.	Series.	Volume.	Whole No. of Vol.	Date of Pub. of Vol.
1841	December	3	10	40	1845
1842	January	3	11	40	1845
1842	January and February	3	11	41	1846
1842	March to April	3	12	42	1846
1842	April	3	13	43	1847
1842	May	3	14	44	1847
1842	May and June	3	15	45	1848
1842	June	3	8	38	1844
1842	July to December	3	16	46	1848
1843	January to June	3	17	47	1849
1843	July to September	3	18	48	1849
1843	October	3	8	38	1844
1843	October to December	3	18	48	1849
1844	January to April	3	8	38	1844
1844	May to October	3	9	39	1845
1844	November and December	3	10	40	1845
1845	January and February	3	10	40	1845
1845	March to July	3	11	41	1846
1845	August to November	3	12	42	1846
1845	December	3	13	43	1847
1846	January to May	3	13	43	1847
1846	June to August	3	14	44	1847
1846	September to December	3	15	45	1848
1847	January to March	3	15	45	1848
1847	April to September	3	16	46	1848
1847	October to December	3	17	47	1849
1848	January to August	3	17	47	1849
1848	September to December	3	18	48	1849
1849	January to April	3	18	48	1849
1849	May to December	3	19	49	1850
1850	January and February	3	19	49	1850
1850	March to November	3	20	50	1851
1850	November and December	3	21	51	1851
1851	January to May	3	21	51	1851
1851	May to November	3	22	52	1851
1851	November and December	3	23	53	1852
1852	January to April	3	23	53	1852
1852	May to November	3	24	54	1852
1852	November to December	3	25	55	1853
1853	January to May	3	25	55	1853
1853	May to November	3	26	56	1853
1853	November to December	3	27	57	1854
1854	January to April	3	27	57	1854
1854	May to October	3	28	58	1854
1854	October to December	3	29	59	1855
1855	January to April	3	29	59	1855
1855	May to November	3	30	60	1855
1855	November and December	3	31	61	1856
1856	January to April	3	31	61	1856
1856	April to October	3	32	62	1856
1856	November and December	3	33	63	1857
1857	January to April	3	33	63	1857
1857	April to September	3	34	64	1857
1857	October to December	3	35	65	1858
1858	January to March	3	35	65	1858
1858	March to September	3	36	66	1858
1858	October to December	3	37	67	1859
1859	January to April	3	37	67	1859
1859	April to September	3	38	68	1859
1859	October to December	3	39	69	1860

THE WESTINGHOUSE CONTINUOUS BRAKE.

It is about ten years since Mr. George Westinghouse first came over to England with the object of inducing railway companies in this country and on the Continent to adopt his system of continuous air brake, which had at that time found a large and very useful application on the railways of the United States. At that time continuous brakes were only exceptionally used on English railways, and not at all on the Continent. Here the necessity for them was realized, but not so fully as a few years later, when the increase in the number of trains and the acceleration of speeds rendered some efficient means of controlling trains absolutely necessary. The Board of Trade took action in the matter by a series of exhaustive trials, and having satisfied themselves as to the requirements of an efficient brake, and also as to what could be done within practical working limits, laid down a series of conditions sufficiently stringent, but capable of being fulfilled by one system—the Westinghouse automatic. This was a very considerable advance over the original Westinghouse continuous air brake, which was, however, until the introduction of the improved system, the most efficient that had been introduced. These trials took place in June, 1875, and were only one series of a large number carried out before and since both in this country and on the Continent, and which proved conclusively the superiority of the Westinghouse brake over all the other systems with which it came into competition. In spite of this undoubted superiority, the adoption of the automatic air brake proceeded but very slowly on English railways, owing to causes with which we need not trouble ourselves now. But however slow this progress, it has been at all events steady, and during the last two years has advanced with more rapid steps, while on the Continent the adoption of the Westinghouse automatic brake may be said, as regards France and Belgium, to be universal. An examination of the results obtained will show, indeed, that Mr. Westinghouse has established his system in Europe on as strong a basis as in the United States. Up to the 25th of November the number of automatic brakes in use or ordered for immediate application were as given in the following table.

Country.	Engines.	Carriages.
England,	1087	7719
France,	1416	7193
Belgium,	359	1728
Germany,	63	105
Austria,	4	32
Russia,	64	51
Holland,	59	208
Italy,	11	35
Sweden,	1	6
India,	6	60
New South Wales,	66	124
South Australia,	27	18
Queensland,	1	11
United States,	3435	12,270
	6599	29,560

In England the system is in use on 14 different railways, the chief of which are the North-Eastern, with 328 engines and 2343 carriages; the London, Brighton and South Coast Railway, with 256 engines and 2116 carriages, and the Great Eastern with 136 engines and 1064 carriages. The North British, the Caledonian and the Glasgow and South-Western also have their stock fitted with the brake. In France the system may be said to be universally adopted, since it is the standard brake on the Western, Ceinture, the Paris, Lyons and Mediterranean; the Orleans and Midi have accepted it. The State railways of France have not yet definitely decided, and the Northern, which for some time has employed the vacuum brake, has still that system in use. There is little doubt, however, that with a uniform system throughout the other railways, the Northern will soon decide on making a change. In Belgium, on the whole *réseau* of State railways, the Westinghouse automatic brake is used, it having been very early adopted by the government, which has every reason to be satisfied with the wisdom of their selection. In the United States it is of course recognized as the standard system, no less than 190 railway companies employing it. As regards the non-automatic or early continuous brake, its use continues to a large extent in America, there being in service on United States lines 2579 engines and 11,389 cars fitted, while in England and the colonies there are 58 engines and 399 carriages running with the

brakes. Thus the total of railway stock to which Westinghouse brakes have been applied and are to-day in use amount to no less than 9236 engines and 41,349 carriages. These figures are more conclusive than any argument could be of the acknowledged efficiency of the system. Despite the hesitation, indifference and in some cases obstructiveness of locomotive superintendents in this country, the example set by Belgium and France (in both of which countries the automatic brake was promptly decided upon) will doubtless be followed here as soon as public and official pressure enforces general action. The Westinghouse Brake Company, Limited, employs more than 500 men manufacturing automatic brake apparatus in their various establishments in Europe, the present capacity for turning out work being equal to 1200 carriages and a proportionate number of locomotives per month.—*Engineering.*

Action of Cold upon the Voltaic Arc.—D. Tommasi publishes the following conclusions from his experiments: When the voltaic arc springs between two metallic rheophores, each formed by a U-shaped tube, traversed by a rapid current of cold water, and placed horizontally near to each other, the following facts are observed: 1. The illuminating power of the arc is greatly weakened, being reduced to a simple luminous point even when a very intense electric current is employed. 2. The arc, if it can be called so, is very unstable; the least breath extinguishes it, and it cannot even light a match without being extinguished itself. 3. If a piece of paper is placed above the arc, and very near it, a black point is formed, which spreads and finally breaks, but the paper does not kindle. 4. The arc consists of a luminous globule, moving up and down between the two rheophores; the form of the globule as well as its extreme mobility reminds one of a drop of liquid in the spheroidal state. 5. If the south pole of a magnetized bar approaches the arc, it is attracted by the magnet and extinguished. The same fact is observed, but in the opposite direction, upon the approach of the north pole. 6. The quantity of ozone seems to be greater than when the arc is not cooled. In spite of the cooling of the rheophores the flame is slightly green, which shows that a portion of the copper is burnt. Tommasi proposes to experiment with platinum rheophores, with alcohol cooled to $-30°$ ($-22°$ F.).—*Compt. Rendus.* C.

Diffusion of Electric Light.—M. Clemandot was induced, by observing the diffusion of the solar light by clouds, to experiment with mineral wool, or spun slag, in connection with the electric arc, and found that it seemed to absorb the light like a sponge, so as to make from 75 to 80 per cent. available for illumination while the ordinary processes utilize only from 45 to 50 per cent. at the most.—*La Nature.* C.

A French Experiment in Ship-building.—During the French blockade by the English fleet Napoleon established a maritime arsenal in Venice, where a number of vessels were built. One day a brig, upon which great expectations had been founded, left the port without having time for trial; but it sailed so slowly that it was captured by an English ship before it reached the open sea. The French crew was replaced by an English crew, which was soon disappointed at finding that it was almost impossible to move the brig. Upon examination it was suspected that the principal mast had been badly stepped. Carpenters were called, who gave the mast a greater inclination, and after spreading the sails anew the brig was found to be a faster sailer than any other in the English fleet.—*Les Mondes.* C.

Speech of Deaf Mutes.—F. Hémant having observed that deaf mutes, when taught to talk, speak with a peculiar local intonation, attributed the fact to organic conformation similar to that of their parents, and regarded it as a new example of physical resemblances transmitted by heredity. Emil Blanchard objects to this conclusion. He says that the voice of those who are deaf from birth is hoarse, metallic, guttural, without modulation or inflection, and free from the ordinary accents of the human voice. Upon learning to speak, the master shows how it is necessary to place the lips, to open the mouth, to close or separate the teeth, to swell the cheeks, in order to produce the various sounds. Thus it is easy to understand that the pupil may copy the accent or intonations of the master. The question whether the presence or absence of certain articulations in the idiom of any people coincides with peculiarities of the phonetic apparatus is still undecided. A final answer cannot be given until several children of races speaking very different and peculiar idioms shall have been taken from their parents in infancy and accustomed to speak some European language. —*Comptes Rendus.* C.

Hiving Bees by Electricity.—Electricity has been successfully applied in capturing swarms of bees which have been collected on walls or trees. If a gentle current is passed through the swarm they become benumbed so that they can be handled without danger.—*Der Techniker.* C.

The Severn Tunnel.—The total length of the Severn tunnel is 3701 metres (2·305 miles). The longest gallery was begun in January, 1875; in October, 1879, the work was interrupted by an invasion of fresh water, when the galleries were within 39 metres (42·65 yards) of meeting. After pumping out the water the work was resumed in August last, and completed in a very satisfactory manner. The breadth of the galleries was only 3 metres (9·843 feet); one of them had an inclination of one foot per 100, which increased the difficulty of surveying; nevertheless, the Monmouthshire section, of 3081 metres, and the Gloucester section, of 620, met without any perceptible deviation. The duration of the work was four years and ten months, including all delays except that of 18 months which was caused by the irruption of the water. The time was lengthened by the narrowness of the galleries and the nature of the rock, which was found to be very hard for more than one-half of the length of the tunnel.—*Ann. des Ponts et Chaussées.* C.

Transformation of Sound into Light.—In 1879, a year before the invention of the photophone, M. Trève made an experiment which is the reverse of the photophone. A Fizeau condenser, consisting of sheets of paper alternating with tin foil, was rolled and placed in a Geissler tube, which was connected with an air pump. The current of a Ruhmkorff coil was passed into the tube, and a telephone was placed in the induced current. While the current was passing, the roaring of the electricity in the condenser could be heard in the telephone. If the pressure of the air in the tube was gradually diminished by the air pump, the roaring subsided; when a vacuum of two or three millimetres (·079 to ·118 in.) was reached the noise ceased altogether, and light began to play against the leaves of the condenser. It was not the well-known vague and diffuse light of the Geissler tubes, but a special, condensed, pearly radiance. It was necessary that the electricity should be manifested in some way, and as it could not be transformed into sound, on account of the rarefaction of the air, it was changed into light.—*Les Mondes.* C.

Chili Saltpetre.—Nitrate of soda is found in great abundance in the desert of Atacama. Under a bed of soil, varying in thickness from 10 to 50 centimetres (3·937 to 19·685 in.), there is a compact layer of gypsum, under which the salpetre is found in irregular beds, with a thickness sometimes reaching to two metres (6·562 ft.). It is often mixed with sulphate of soda. It comes from the decomposition of the feldspathic rocks, and, as these rocks form the central part of the desert, the supply seems to be almost inexhaustible.—*Les Mondes.* C.

Storms and Sun Spots.—M. L. Cruls, in collecting materials for the study of the meteorology of Rio de Janeiro, was struck with the remarkable variation in the annual number of storms. Knowing the importance of the electromagnetic action of the sun in many of the physical phenomena of the globe, and the evident relation that exists between the periodicity of some of these phenomena and that of the sun spots, he instituted a comparison which showed a remarkable similarity between the curves representing the annual number of storms and the relative number of sun spots in Brazil. He found a similar accordance, though less striking, in the records of the Toronto Observatory. Faye regards this communication as a very striking confirmation of the views which he has been advocating for many years.—*Comptes Rendus.* C.

Manageable Anæsthetics.—Paul Bert has been experimenting upon the anæsthesia of animals with mixtures of variable proportions. He calls the interval between the anæsthetic dose and the mortal dose the manageable zone, and his experiments seem to indicate that in all cases the mortal dose is just double the anæsthetic dose. If the mixture represents about the middle of the manageable zone, an animal is quieted very rapidly, and remains tranquil during the whole time of the experiment, even if it lasts for a period of two hours. A few drops of the liquid, if they are breathed without a proper mixture of air, may suffice to carry the patient from the manageable to the mortal zone. Most anæsthetics seem to act, not by the quantity, but by the proportion which they hold to the air that is breathed. It seems probable that these proportions may be so exactly ascertained that all anæsthetics may be used with perfect impunity.—*Comptes Rendus.* C.

Influence of Telegraph Wires upon Birds.—In the neighborhood of the pine forests of Norway the telegraph posts which have been freshly impregnated with sulphate of copper are often found to be entirely perforated by the woodpeckers. The resonance, which is produced by the vibrations of the wires, leads the bird to suppose that there are worms and insects in the interior, and holes are consequently made which are sometimes as large as a man's arm. They are generally found near the insulators.—*La Nature.* C.

Gigantic Algæ.—The *Madras Mail* contains an account, by Captain Taylor, of an enormous monster which he saw while at anchor in Table Bay. It was more than 100 feet in length, and appeared to glide over the water with an undulatory motion, like a serpent. Its head seemed to be surmounted by something like a long mane, and the observers who had the sharpest sight affirmed with fear that they could distinguish its features and even its eyes. He collected the crew and directed a brisk fire of musketry upon the monster, at a disance of about 500 yards. When it seemed to have been seriously injured, and its movements were a little quieted, boats were sent out to examine it more closely and to finish its destruction. It was then found that they had been fighting a magnificent specimen of the *giant herb of the sea*, of which the undulatory motions were caused by the agitation of the waves near the shore.—*Les Mondes.* C.

Bears, Wolves and Telegraphs.—The director of the Norwegian telegraphs says that the bears are often attracted by the humming of the wires, which sound they suppose to come from a swarm of bees. On reaching the posts and finding no hive they think it is hidden under the heap of stones at the foot of the post, and scatter them in all directions. When the first telegraphic lines were established in Norway a member of the Stortheig stated that, although his district had no direct interest in the proposed line, he would vote for the appropriation, because, in his opinion, the wires would drive the wolves from the whole region. It had already been noticed that wolves, however hungry they might be, would never enter yards which were closed by simple cords stretched between posts. Whether for this reason or for some other, it is a fact that since the line was established, a period of more than 20 years, the wolves have disappeared. —*L'Electricien.* C.

Franklin Institute.

HALL OF THE INSTITUTE, Dec. 21st, 1881.

The stated meeting was called to order at 8 o'clock P.M., the President, Mr. William P. Tatham, in the chair.

There were present 139 members and 28 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers and announced that at the last meeting of the Board 26 persons were elected members of the Institute.

The President announced that nominations for officers to serve the ensuing year were, in accordance with Article XIV, Section 7 of the By-laws, the privileged business of the meeting; and, after the reading of the names of those whose terms would expire, he asked for nominations.

The following members were placed in nomination:

For President, William P. Tatham.

" *Vice Presidents* (to serve for three years, and for the unexpired term of Mr. Cartwright), J. E. Mitchell and Frederick Graff.

For Secretary, Dr. Isaac Norris and Dr. W. H. Wahl.

" *Treasurer*, Frederick Fraley.

" *Managers* (to serve for three years), William Sellers, J. Vaughan Merrick, Hector Orr, Cyrus Chambers, Jr., Prof. William D. Marks, W. V. McKean, Henry R. Heyl, Dr. Robert E. Rogers.

For Auditor (to serve for three years), W. B. Cooper.

" *Trustee in Pennsylvania Museum and School of Industrial Art*, Dr. Isaac Norris.

Prof. Rogers, chairman of the Committee on the "Precautions to be taken to obviate the dangers that may arise from Systems of Electric Lighting," presented the report, which was published in full in the December number of the JOURNAL.

Prof. Rogers suggested that, as the paper had been published, the reading of it could be dispensed with; and Mr. Mitchell, endorsing it as an admirable one, moved that it be adopted.

Mr. Shaw thought that some members, although they had received copies of the report, had had no opportunity to read it, and said that they should not be called upon to adopt it without knowing what it

contained. He had not read it, and thought it would be better to postpone its consideration until the next meeting.

Objection was made to postponement, and the President deciding that the reading had been called for, all motions on the subject were withdrawn and the Secretary read the report from the printed copy.

Prof. Rogers said that the committee had given a great deal of solicitous thought to the subject and worked up all the problems presented to them. He wanted to emphasize some of the recommendations of the report. One of these was the necessity of making good connections, not liable to be broken or impaired by jarring, especially where short pieces of wire were used. Another important matter was to have the wire sufficiently thick to carry the current without heating. He emphasized these points by telling of an accident which occurred to one of the electric lights on Chestnut street, and which he witnessed. The light having been extinguished from some cause, about a yard of copper wire was heated to a red heat by the current, and this ignited the combustible insulating material by which the main conductor was covered. The copper was also melted, and a voltaic arc formed in the copper vapor. It was easy to see how such an accident in a building might create a fire, and this demonstrated the necessity of observing the precautions recommended by the committee.

The report was then adopted by a vote which appeared to be unanimous; and, on motion of Mr. Mitchell, the thanks of the Institute were tendered to the committee for their valuable services.

Mr. Hector Orr then addressed the Institute briefly on the progress made and being made in the silk and flax industries of the country. He recalled the aid given to these industries by the Franklin Institute, especially in the development of machinery for the manufacture of textile fabrics, declaring that Philadelphia had done more in the way of improving such machinery than all the rest of the world "since Egypt first wrapped her mummies in linen made of flax." He said, in conclusion, that he thought the Institute ought to be promptly given the $200,000 required for its proposed new building, this being "only one-fourth of one per cent. of the sum represented by the annual trade of these two staples, the manufacture of which has been fostered by the Institute."

Mr. William Barnet LeVan read a paper on rapid transit, in which he advanced the idea that railroads would eventually be used only for carrying freight, and that passengers would be conveyed from one

place to another by the pneumatic system, at higher rates of speed than are now attainable on steam railroads. He described the general features of a pneumatic road which, he thought, should be built on Market street, instead of the proposed elevated railroad, and said that its first cost, as well as its running expenses, would be less than that of a steam railroad. His plan contemplated the building of two ten-feet tunnels, one for up and the other for down trains, finished smooth on the inside and made air-tight. The cars would be of iron, cylindrical in shape and with seats for passengers running lengthwise. They would be propelled by atmospheric pressure, fans driven by stationary steam engines at various points on the line exhausting the air in front of them. He described how arrangements could be made to stop the cars at stations, or to allow them to pass as express trains, and how the movements of trains could be indicated in the station and engine blower rooms. Pneumatic tubes are now used for the transmission of messages, packages, etc., in many places, and in London there is a tunnel, 4½ feet in diameter, used for the transmission of the mails a distance of two miles. Several people have made the trip in the mail cars, the first to do so being the Duke of Buckingham and some friends, as long ago as October 10, 1865. They were transported through the tube at the rate of 12 miles an hour. Mr. LeVan expressed the opinion that the pneumatic system would do away with most of the existing objections to railroads on which steam is used as the motive power, and looked forward to the day when such a road would connect the cities of New York and Philadelphia.

Mr. Shaw inquired whether any allowance had been made for the frictional resistance of the air column in a long tube such as that between New York and Philadelphia would have to be.

Mr. Le Van said that he proposed to overcome whatever resistance there might be by having a number of engines and stations. In reply to other questions Mr. Le Van said he proposed to use rubber or leather for packing.

Prof. Rogers inquired whether he had made any arrangements to preserve the lives of the passengers traveling at the proposed speed and under the compression required to maintain it.

Mr. Nystrom said that the difference in pressure would not be greater than that between the pressure at the sea level and on a high mountain.

In reply to further inquiries Mr. Le Van said that the proposed size

of the wheels was 48 inches, and that the estimate of the cost of laying the tube between Philadelphia and New York, sometimes under ground and sometimes above ground, was about $60,000,000, and that this would be less than the cost of an elevated road.

Wendell's Car Journal Box was shown in various forms, and was described by Mr. C. Henry Roney, C.E. In cars and locomotive engines the weight of the vehicle rests upon the axle, and the lubricator of the latter, to be effective, should be on the top of the journal. In the ordinary box, cotton waste, saturated with oil, is employed as a stuffing, so that the oil may be carried up by capillary attraction to the journal. It answers the purpose only imperfectly, however, sometimes collecting dust on its surface and sometimes dropping away and leaving the journal without lubrication and exposed to the dangers of heating. In the box invented by Mr. Wendell no stuffing is employed, but in place thereof there is a small force pump, with ball valves, operated by the vertical motion of the car on its truck. The oil is thus automatically pumped from the bottom of the box to the top of the bearings, through which are openings carrying it direct to the top of the journal, whence it falls to the bottom of the box. A leather or cork shoulder packing is used to prevent the escape of oil or the admission of dust. The boxes are made in three forms: one for steam railway cars, one for street cars, and one as an attachment to be put in place of the door or lid on boxes now in use. The inventor claims a very great saving in brasses and lubricants by the use of this box.

Mr. Roney also exhibited photographs of Thompson's Patent Wet Pulverizer, manufactured by S. P. M. Tasker, for which also the chief claim is economy. It is claimed that in stamps one shoe weighing about 300 pounds will crush forty tons of quartz rock before being worn out, while this pulverizer, with a ball weighing 180 pounds (which is the crushing part) will crush three hundred tons of the same rock fine enough to pass through a 60-mesh screen. The first cost is also said to be less than for stamps in ordinary use.

Mr. Washington Jones mentioned some stamps now in use which pulverize 100 tons of quartz rock per stamp in twenty-four hours, and said that the wear of shoes amounted to about a quarter of a pound of iron per ton of crushed stone.

Mr. Roney said that this was about the same as the wear claimed for Thompson's pulverizer.

The Secretary's report on new inventions, of which models or sam-

ples were exhibited, included the following: Burgess' Air Compressor, which is adapted for physicians' use, for spraying the throat and nasal passages, for atomizing in surgery and for disinfecting rooms, hospitals, etc. The air pump is operated by foot power.

The Zimmerman's Students' Lamp is an elaborate arrangement for lighting the ordinary oil lamp without the use of matches, and for extinguishing without the risk entailed in blowing down the chimney. Opposite the lamp on the standard is an electrical battery and a jar in which hydrogen gas is generated. The battery is used to heat a platinum wire which in turn lights the gas, and that, being directed against the wick of the lamp, lights it. The extinguisher is a rubber ball connected with the central draft tube of the lamp. By compressing the ball a current of cold air is directed against the flame from below and extinguishes it.

Pfautz's Elevating Tower was exhibited in model. It is an extensible apparatus, designed to furnish a platform which may be raised and lowered and used as a fire-escape. The frame or truck is mounted on wheels, so that it may be easily shifted from one place to another.

Kurtz's Fire Ladder, an extensible ladder, mounted on a wheeled truck, was also shown in model.

William R. Fowler's Cloth Cutting Machine was exhibited by the American Cloth Cutting Machine Company. The cutting bed is studded with short vertical wires, on which the cloth rests. The cutters, driven by steam power, are mounted on the end of a flexible arm. They cut upward against a pressure plate on top of the several layers of cloth, and pass freely around the wires on the cutting bed without injury to the knives.

Dr. W. G. A. Bonwill's Dental Engine, also adapted to use in surgery, was exhibited and explained by the inventor. It is run by foot or hand power, circular saws, drills and other cutting instruments being affixed to the end of a flexible arm and revolved at a very high rate of speed. The bones of the body can be drilled or cut in any desired manner with great speed and exactness by the use of this engine.

Prof. Rogers said that Dr. Bonwill's engine deserved recognition as a means of alleviating pain by expediting the work of surgery.

A resolution inviting publishers to send copies of new books to the Institute for notice in the JOURNAL was referred to the Committee on Library.

Mr. Mitchell reported that the Committee on Exhibitions, after examining Industrial Hall, and considering the question of holding an exhibition of small apparatus there during the present winter, had come to the conclusion that it was inexpedient to hold such an exhibition at this time.

On motion, the Institute adjourned.

ISAAC NORRIS, M.D., *Secretary.*

LIST OF BOOKS ADDED TO THE LIBRARY DURING OCTOBER, NOVEMBER AND DECEMBER, 1881.

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